Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

INCLUDING THE *Journal of the Instrument Society of America*
AND THE *Journal of the Southern California Meter Association*

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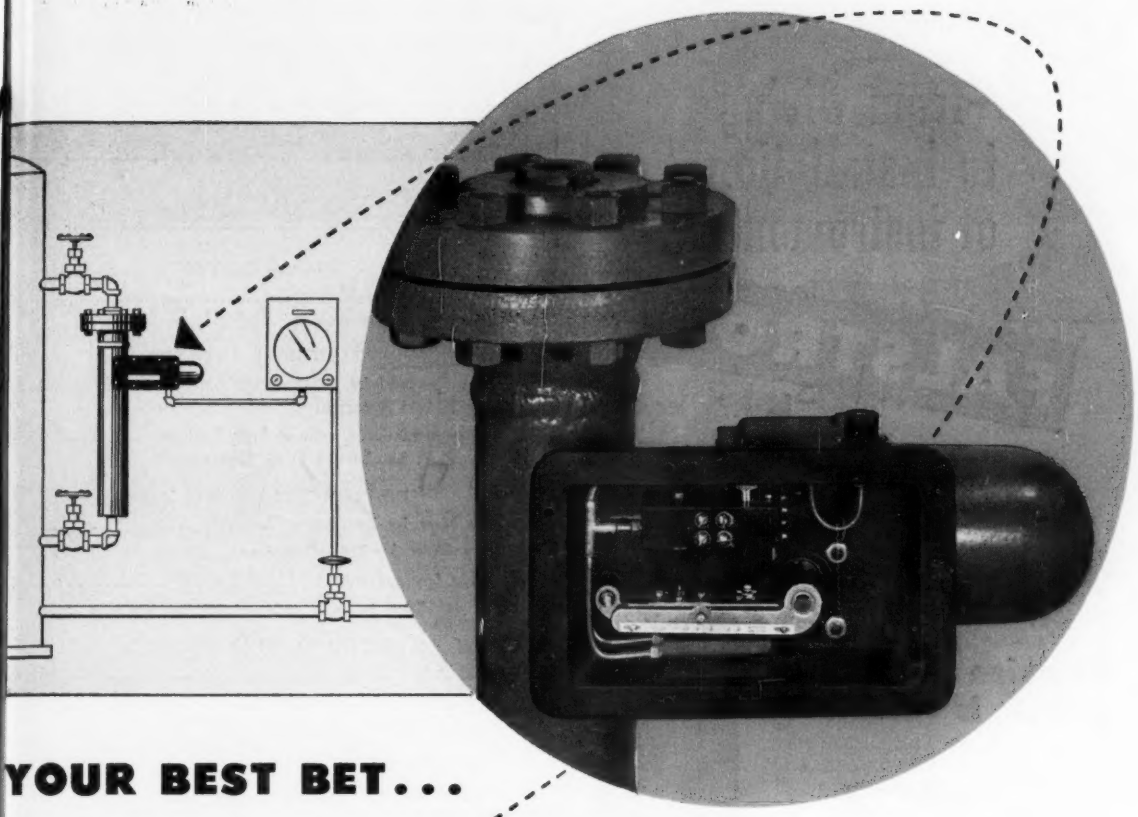

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Instruments

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

REPORT ON WESTERN EUROPE

First Article--My Visits to Industrial Fairs--Mostly Pictorial

By RICHARD RIMBACH, Publisher of *Instruments*

I LEFT Idlewild International Airport on the Air-France Constellation Bazh at 7:30 p. m. on Wednesday, March 29th and arrived at Orly Field, Paris, at 2 p. m. the following afternoon an actual flying time of 12½ hours. I stayed in Paris only to transfer from Orly Field to Le Bourget to fly to London, arriving there late on Thursday evening.

The Physical Society's Exhibition started on Friday morning in the Physics Department of The Imperial College, London. This exhibition is not a trade show. The Imperial College Physics Department provides all facilities and space free. The exhibitors do not pay for their booths and a company cannot exhibit unless invited. Products shown are in most cases new developments, and the size of space and the products to be shown are determined by a committee of the Physical Society. Mr. A. Peacock, Secretary of the Scientific Instrument Manufacturers Association, is Exhibit Director.

One of the most important features of the Exhibition is the specially produced Handbook of Scientific Instruments and Apparatus. This volume is a complete guide to the Exhibition and contains detailed descriptions of the exhibits. While it is of great value during the Exhibition, its main purpose is to provide a future source of information and it also serves as a unique compendium of up-to-date detail on physical apparatus and methods. This Handbook has 266 pages covering a total of 136 exhibitors of which 13 are Government laboratories, 6 are Universities, 6 are publishers, 4 are trade associations and the balance are commercial firms.

The exhibition lasts from Friday until the following Wednesday, excluding Sunday. This was the 34th exhibition and the fifth to be held since the war. In addition to commercial firms, the research sections of British government departments and trade associations show examples of the physics research they are carrying out. It would have been difficult to pick out particular instruments in a show in which nearly all devices shown are classified as new developments. To obtain the information given below your reporter requested each one of the exhibitors to furnish a brief description and a suitable photograph of each new development shown. Many of the exhibitors, as will be obvious, did not follow this suggestion.

In our August issue, Part II of Mr. Rimbach's report will cover the Hanover Fair, the British Industries Fair and the Paris Fair. In Part III (September) he will give his opinions of the markets, production, *Productivity*, and various trends.

Mr. Rimbach shipped from Europe a number of Exhibit guides, various other booklets (some of them in three languages), photographs, etc. — all of which are on display in the office of *Instruments*, 921 Ridge Ave., Pittsburgh 12.

After the close of the exhibition, I visited instrument manufacturers and instrument users in various parts of England. I also attended meetings of the Society of Instrument Technology at Manchester and at Stockton-on-Tees.

I returned to London April 17th, at which time the Radio and Electronic Component Manufacturers Federation's Exhibition opened. This show was held in the ball room of the Grosvenor House and is the 7th exhibition held by Federation. The show opened on April 17th and ran through and including April 19th. A 164-page official catalog and yearbook is published in connection with the exhibition.

The first exhibition was held in 1944 and it has been held annually since then. 102 exhibitors occupied booths of 100 sq. ft. area each. This exhibit showed the most recent advances in the design and development of British radio, television and electronic components, tubes and accessories, radio and television test gear and instruments and materials used in their manufacture.

A NEW RECORD

Our New Instruments department this month includes 130 items — a new high.

On April 19th I flew from London to Lyon, France, to visit the Lyon Industrial Fair. This Fair was first held in 1916. The main building at the fair is 1200 feet long and 54 feet wide with 24 wings, 4 stories high; each single story wing has 100 booths of 172 sq. ft. each. Another building has 360 shops of the same size. This represents a total of over 500,000 sq. ft. under roof. In addition there were large areas of outside exhibits. This Fair is a sample fair, and no sales are made at the fair. There were no instruments shown at this Fair. In fact the Fair looked very much like one of our large country fairs.

The official catalogue of the Lyon Fair, printed in French, consists of 800 pages and in addition to an alphabetical list of manufacturers an index of products with their manufacturers; also divides the products into 52 product groups and in each group lists the company name, address, booth number and location and a brief description of products manufactured. Exhibitors' advertisements are also included.

My next stop was at Basle, Switzerland, where the Swiss Industries Fair is staged. This is the 34th annual fair and 2200 exhibitors used about one million square feet of display space. Products exhibited are limited to those manufactured in Switzerland, and here they had very excellent exhibits devoted to watches, industrial instruments as well as instruments for use in inspection and gaging. The fair management is rather rigid as concerns the taking of pictures or making notes on any of the products shown. The displays at this fair were very well arranged and many of the exhibits were interesting and very attractive. The catalogue of the Swiss Industries Fair is printed in four languages; German, French, Italian and English and is bound into two parts. Part I consists of 224 pages and includes a list of the exhibitors, their address, a brief product listing and booth number and location. Part II has 920 pages and contains a product index and finally a listing of companies by product groupings. The booth location is also included in Part II.

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It was not possible to ferret out the new products in measurement and control devices as to obtain information in Switzerland is rather difficult, due to the fact that the Swiss consider many things concerning such details as industrial espionage. Many Swiss industrial instruments appear to be very similar in appearance to pre-war German instruments. The general impression I received was that there are very few instruments manufactured in Switzerland that are not already available in the United States.

There are no restrictions on the importation of instruments into Switzerland but the electrical requirements are very rigid and it would be well to check these requirements when thought is given to the possibility of exporting to Switzerland. I was told that there were no instrument departments in the Swiss user companies, and I believe this is largely due to the fact that most of the companies are small. This small size of company is both a matter of strength as well as a possible weakness of the Swiss industries, as there are many small manufacturers consisting of the owner and three or four employees. The employer works long hours and usually combines the plant with his home.

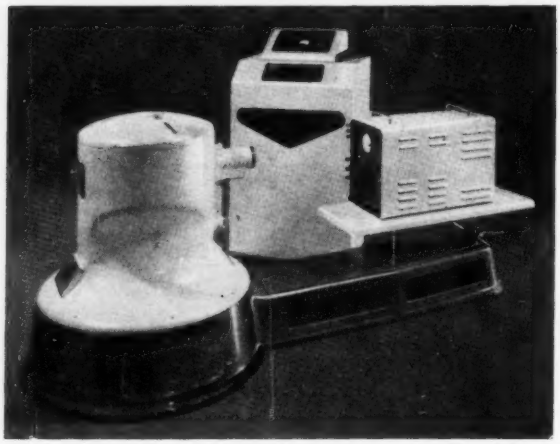
New Instruments Shown at the Physical Society's Exhibition at the Imperial College, London, March 31 to April 5.

Transmission type interferometer microscope utilizing a compact optical system which can be incorporated in most standard type instruments. Interference contrast is obtained by superimposing two fields, one containing the light source alone and the other the light source with the object superimposed. A simple translating adjustment attached to one component allows a continuous change of phase difference between the two images. (Associated Electrical Industries Ltd.)

A long working distance microscope objective system used in conjunction with a conventional microscope objective allows a very much increased working distance to be obtained. The working distance of this system is sufficiently great to allow of the examination of emulsions through the glass of the plate, or even through a pile of plates. (Associated Electrical Industries Ltd.)

The resistor network is an apparatus for the experimental solution of certain partial differential equations (e.g., Laplace's and Poisson's equations, and the wave equation), for prescribed boundary conditions. One can consider it either an electrolytic tank analog in which the continuous conductance of the electrolyte has been replaced by lumped conductances, or a computing machine applying automatically and instantaneously the relaxation technique. The solution is of a high degree of accuracy (1 part in 1,000 to 1 part in 10,000) because the network has the property of averaging errors. (Associated Electrical Industries Ltd.)

Electronically controlled self-loading drum camera has film speed of 3,000 inches per second, permitting the recording of cathode ray oscillograph traces resulting from transient phenomena occurring in millionths of a second.

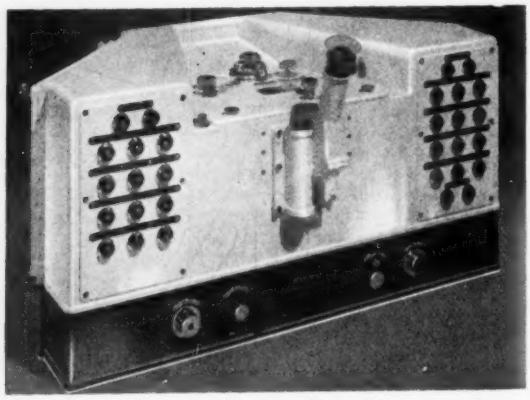


This terrific speed is obtained by rotating horizontally under electronic control a 16 inch dia. drum at 3,600 rpm. resulting in the periphery, to which the film is attached, travelling at a velocity of some 170 miles per hour. (Avimo, Ltd.)

Oscillograph recorder useful for applications where the camera is subject to excessive vibrations. The complete mechanism lens housing and cassette holders are mounted on a separate plate and housed in a sheet metal case pre-

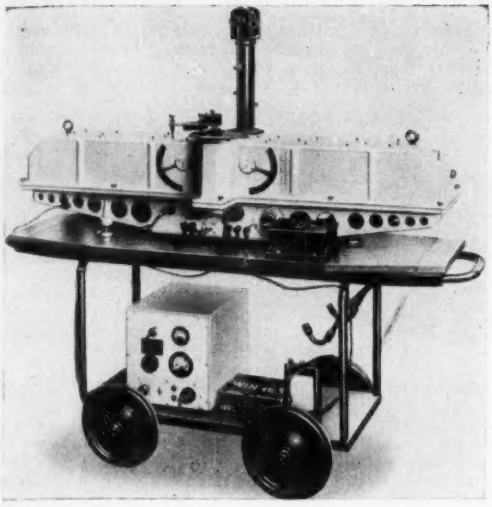
formed for strength and rigidity. This camera can be operated in temperatures below freezing point, since a thermostatically controlled heater can be fitted. (Avimo, Ltd.)

Fifteen channel oscillograph camera. Adjustable mirrors, one for each tube, are arranged in two batteries to reflect the traces accurately along the axis of each lens. The traces



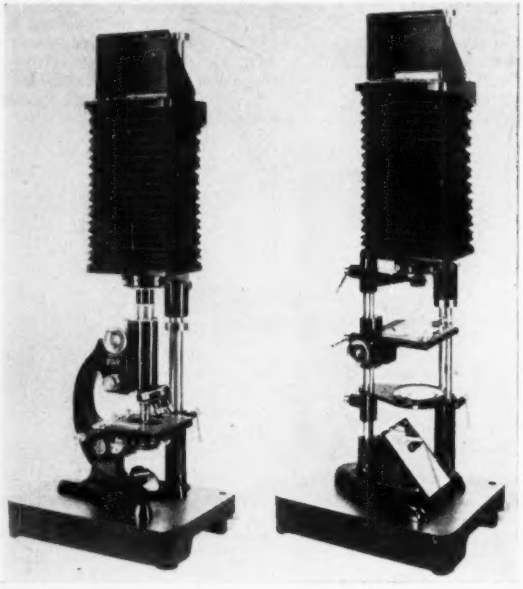
are focussed on to a vertical zero line and the tubes are staggered so as to allow the 15 traces to be accommodated across a space of 60 mm. which is the effective recording width of the 70 mm. film. (Avimo, Ltd.)

Photoelectric ozone spectrophotometer to determine the amount of ozone in the upper atmosphere by measuring the absorption of ultra-violet radiation from the sun in



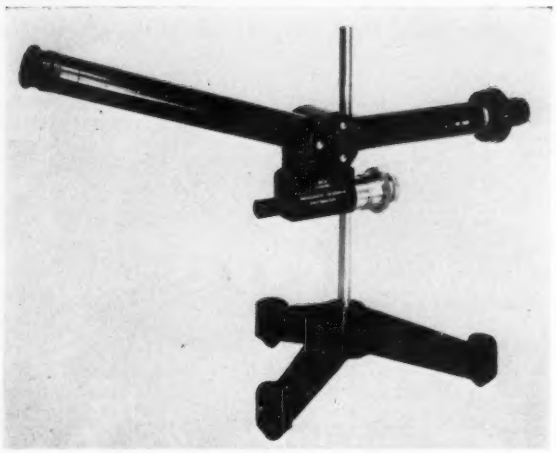
passing through the atmosphere. Light enters a window in the top of the instrument and after reflection in a right-angled prism falls on the slit of monochromator. The required wave-lengths are isolated by means of slits in the focal plane. (R. & J. Beck, Ltd.)

Vertical camera for both micro-photographic and macro-photographic work consists of a heavy base-plate with a machined topface measuring 12 in. by 9 in., to which is rigidly fixed a substantial vertical pillar. This pillar carries a ¼ plate camera which can be adjusted for height and has a bellows extension between 5 in. and 15 in. The



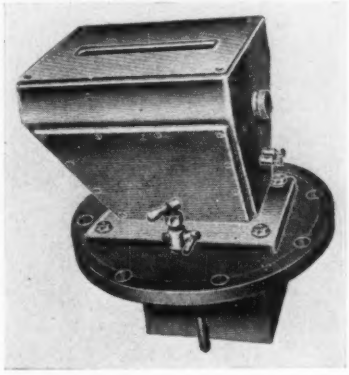
camera is provided at its lowest end with an R.M.S. thread into which the lenses are fitted. Immediately above the lens is a shutter with simple bulb action. The photographic plate, ¼ plate size, is carried in the normal type of single plate-holder. A gray-glass focussing screen is provided and to facilitate its examination during focussing, a 45° reflector is fitted above it. (R. & J. Beck, Ltd.)

Wavelength reversion spectroscope in which two spectra are produced, one above the other but with the colors reversed, permits of the greatest accuracy in setting, especially in the case of absorption bands where the outer edges of the bands are often very indefinite, or when the light in-



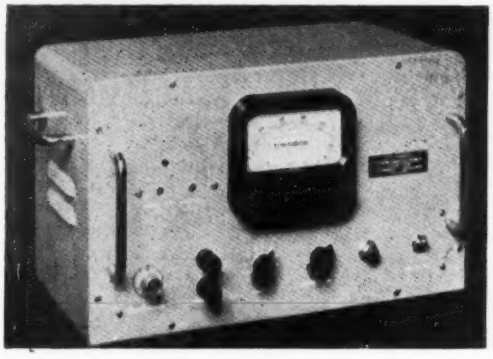
tensity is low, making it very difficult to distinguish the crosslines. By means of a micrometer screw the spectra are moved relative to each other in opposite directions, so that any line or band can be made to coincide with the same line or band in the other spectrum. (R. & J. Beck, Ltd.)

Pan refractometer gives directly the refractive index, or sugar content, on an open scale without the need of further optical aid. With this type of refractometer very dark, or even opaque solutions can be measured, as the re-



fractive index, or sugar concentration, depends on the critical angle of the reflection inside the prism, and not on the transmission of light through the sample. (Bellingham & Stanley, Ltd.)

Apparatus designed for the investigation into noise sources and for the production testing of appliances where



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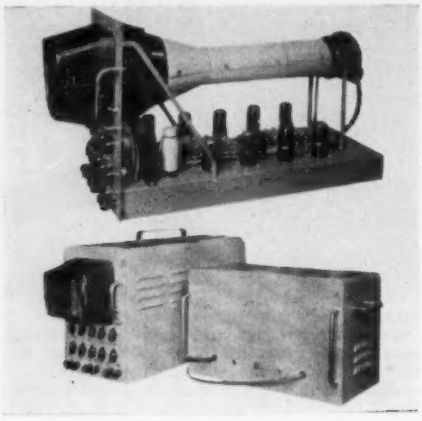
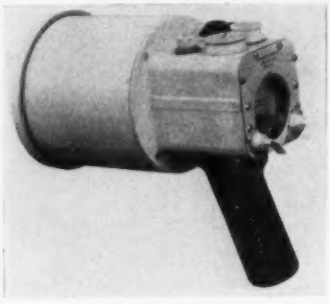
the limitation of noise is an important factor. (A. E. Cawkell)

Oscilloscope is designed for observing and comparing slow waveforms for which the normal instrument is unsuited,



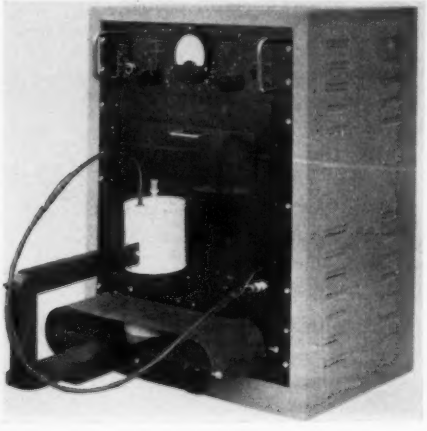
and waveforms of frequency as low as 0.1 cps. may be easily observed on the long persistence cathode ray tube. (A. E. Cawkell)

Completely self-contained and portable ionization chamber type radiation monitor, for use with x-rays and will



give accurate indication of dosage of very soft radiation. The ranges are 0-15 and 0.150 milli-Roentgens per hour. (E. K. Cole, Ltd.)

Radioactive thickness gage with suitable additional equipment, control the thickness of strip material. Size: 24" wide x 20" deep x 24" high, weight 50 lbs. (E. K. Cole, Ltd.)

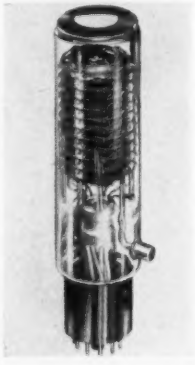


Vibrating reed electrometer consists of two units, th head amplifier and the main amplifier. These are connecte by cables which may be set up to 125 feet in length. Th applied d.c. is converted into a.c. by means of a vibratin

condenser, the a.c. is amplified and then rectified. Stability is increased by the application of negative feedback. Direct indication of the voltage or current being measured is given on a 3½" panel meter and simultaneously a recorder and/or a process controller may be operated. This electrometer is expressly designed for Ionization current measurements. (E. K. Cole, Ltd.)

Sound and Vibration meter is a portable instrument for measuring sound intensity directly in decibels referred to a zero of the threshold of hearing. Variable weighting networks enable the instrument response to be set for low, medium and high intensity measurements. The direct-reading meter may be damped to measure average noise level, though it normally has a fast response approximating to that of the human ear. Used in conjunction with the sound level meter, an analyzer permits measurement of the relative amplitudes of the component frequencies in a sound wave. The frequency control and the amplitude meter are directly calibrated, thus facilitating the measurement and enabling noises to be traced to their sources. For vibration measurements in the frequency range 25 to 1000 cps. the microphone of the sound level meter may be replaced by a vibration adaptor unit. This pick-up generates a voltage when held on a vibrating body, signals proportional to displacement, velocity or acceleration being switched as required to the meter which gives direct readings of these quantities. (Dawe Instruments, Ltd.)

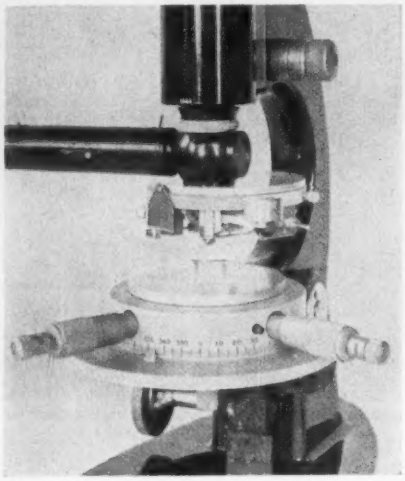
(Dawe Instr.)



(E.M.I.)

Photoelectric electron-multiplier adapted as a scintillation detector to receive the scintillation of a phosphor in intimate contact with the end window of the tube on the inner face of which is a transparent photo-cathode. Parallel to and at increasing distances from this photo-cathode, are eleven secondary emitting electrodes, or dynodes, at each of which the incident electron current is multiplied. Under operating conditions, i.e. with steps of 160 volts between adjacent dynodes, and a total over-all potential of 1920 volts the multiplication per stage is about 4 and the over-all multiplication is approximately 10^7. Thus an alpha-particle scintillation produces an output current capable of modulating directly an oscilloscope beam. (E. M. I. Research Labs. Ltd.)

Bench Type Micro-Hardness Tester designed for use with a standard bench type metallurgical microscope having a suitable graticule consists of a counter-poised beam carrying a special 136° pyramid diamond indentor mounted on a

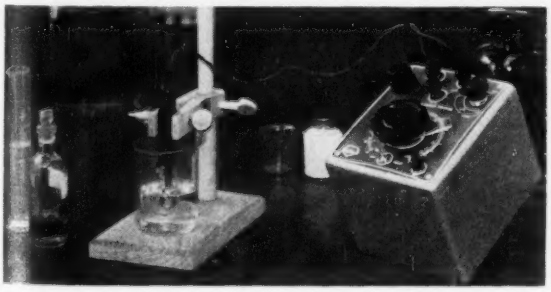


spring located revolving head, which also carries two centralizing adaptors for standard microscope objectives. (Hall Telephone Accessories Ltd.)

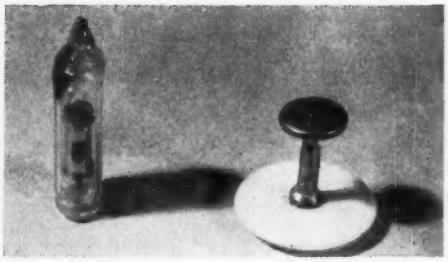
Absolute pressure gage designed to measure the absolute pressure of a gas by admitting it into a flexible metal capsule whose deflection is determined by a suitable linkage and

gear train. Variations in the ambient pressure are compensated for by introducing the movement of an evacuated capsule unit into the linkage system. (Kelvin & Hughes, Ltd.)

Laboratory measurement of conductance using conductivity bridge and dip cell. Instrument is basically a modi-

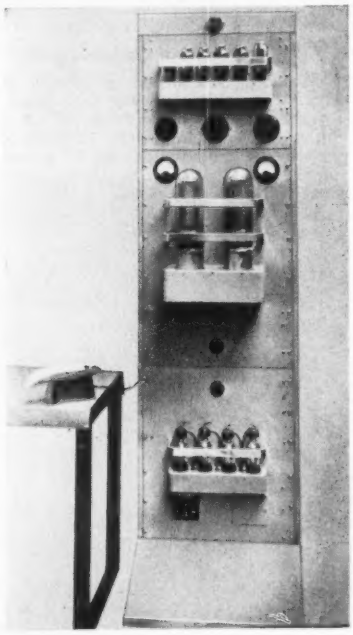


fied Wheatstone bridge operating at a test frequency of 2.9 Kc/sec. (Mullard Electronic Products, Ltd.)



Flat subminiature tube developed especially for use in hearing aids. (Mullard Electronic Products, Ltd.)

Low-frequency ultrasonic generator consists of two parts: the main unit comprising a driving oscillator, power amplifier and low voltage D. C. power supply, together with necessary monitoring and check meters; and the transducer unit composed of a stack of nickel laminations wound with



a common coil for excitation and for polarization. The amplifier which provides the source of power for the transducer is basically similar to a proved design of public equipment, and delivers a maximum output of kilowatt over a frequency range 10Kc/s to 25Kc/s. (Mullard Electronic Products, Ltd.)

Color comparator making a direct assessment of the color differences between two specimens. Direct reading of difference of the two specimens are alternately presented to a photocell by means of a slotted shutter rotating before them. If identical cell receives a steady illumination and has a d-c. output, while any difference between them results in a flicker on the cell and an a-c. component in its output. This a-c. component is separated from the d.c. amplified and indicated on a meter. The specimens are illuminated normally and the cell receives light diffusely reflected at 45°. Colored filters can be inserted in front of the photocell. (Nash and Thompson, Ltd.)

Flowmeter for measuring flow of air or other gases in pipe lines. The principle employed is to supply heat to the air at a constant rate and to measure the consequent temperature rise differentially by a pair of platinum grids, whose resistances vary with the temperature of the air. The instrument is made in two parts. A section of tube about five inches long, with flanged ends for bolting into a pipe line, contains the heaters and thermometers. This head is connected by a length of cable to a meter box con-

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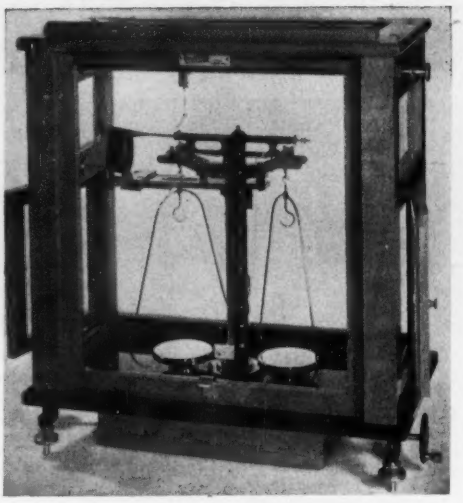
taining the measuring equipment and the stabilizing source of heater current. The two platinum grids and the heating coil between them are spaced evenly across the tube so that readings are substantially independent of flow pattern, providing that the flow is sufficiently great to be fully turbulent. (Nash and Thompson, Ltd.)

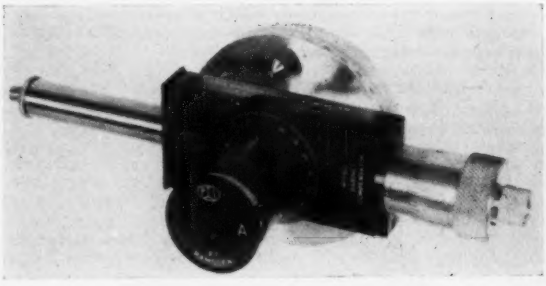
Sensitive pressure controller has many applications when it is desired to stabilize flow or pressure within very fine limits. Pressure differences applied inside liquid-sealed bells cause a beam to tilt and move a vane between a light and split photocell. The arrangement is such that the output of the cell is proportional, in both sense and magnitude, to the deviation of pressure from its standard value. The photocell output is fed through an amplifier to control the field current of a split field motor generator. By means of feedback from the generator section the motor generator speed is made proportional in magnitude and direction to the out of balance emf. to the amplifier. This motor-generator shaft drives, through a reduction-gear a variable-ratio auto-transformer which in turn supplies power to the fan motor. Consequently, any deviation of pressure from standard alters the speed of the fan in the sense necessary to correct the deviation, and the bigger the deviation the faster the change is brought about. The control thus exerted is very stable and 'hunting' is reduced to minimum. (Nash and Thompson, Ltd.)

Aperiodic Null-point Gramchain Balance; sensitivity: 0.1 mg.; capacity: 200 grams in each pan; beam: 5" gunmetal; beam serrated into 10 parts from "0" on the left to "10" on the right and adjusted with a 0.5 gm. rider at zero, each serration being equivalent to 0.1 gram, giving a total displacement of 1 gram. The chain column has a weighing range from 1 mg. to 100 mg., and readings to 0.1 mg. are obtained by means of a vernier. (L. Oertling, Ltd.)

Babinet compensator consists essentially of two quartz wedges of equal angle, placed so as to form a plane parallel plate. The optic axis in the wedges are at right angles. One wedge is movable by a micrometer screw to which is fitted a graduated drum. The complete compensator may be rotated about an axis perpendicular to the basal planes of the wedges, and its angular position read to 0.1 degree by readings on a circle and vernier. The compensator is fitted with an analyzer, the angular position of which may be read from a circle divided to 2 deg. (Precision Tool & Instrument Co. Ltd.)



(Oertling)



(Precision Tool & Instr.)

Exhibition of Radio and Electronic Component Manufacturers Federation, Grosvenor House, London, April 17-19.

Swiss Industries Fair
Basle, Switzerland, April 15-25

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Solution Conductivity Measurement

By ROBERT ROSENTHAL, Chief Chemist, Industrial Instruments, Inc., Jersey City, N. J.

IN the three-quarters of a century since Kohlrausch's first publication of the method of measuring electrolytic conductivity, surprisingly little fundamental change has been made in either the apparatus or the technique. His successful application of the alternating-current Wheatstone bridge, and of conductivity cells with platinized electrodes, quickly and firmly established solution conductivity measurements as a laboratory tool. The literature of these 75 years is replete with data on the conductivity of electrolytes and with voluminous details of its service as an analytical tool. Nevertheless, widespread application in industry has begun only recently. It is likely that one of the reasons for this has been the comparative complexity and high cost of commercially-available bridges and the fragility of conductivity cells. A contributing cause is certainly the rather complex form in which the standard compilations of conductivity data have been presented in this country. I refer here to the general preoccupation with the "equivalent conductance," significant in theoretical studies of electrolyte properties but of no value to the man in the plant who is interested in concentration measurement and control.

During the last ten or twenty years, this weakness in regard to industrial usage has been changing continuously for the better and at an ever-accelerated pace. The tremendous growth of interest in all instrumentation and the general recognition of its sound economic basis has established many new fields of application of conductivity equipment and has extended and crystallized existing usages. During this same period simple and relatively inexpensive bridges and controllers and sturdy conductivity cells designed for plant service made their appearance and are now readily available from at least two sources in the United States. It is my plan to discuss a number of the important industrial uses of conductivity equipment but, before elaborating on these, it would be worthwhile considering the principles and design of the measuring system and the primary element and to touch upon the characteristics of conducting solutions.

Electrolytic or solution conductivity is a measure of the ability of a solution to carry an electric current. It is also called specific conductance and is defined as the reciprocal of the resistance in ohms of a 1-cm. cube of the liquid at a specified temperature. The unit of specific conductance is the reciprocal ohm or mho. Since this is a very large value of electrolytic conductivity, the practical unit is commonly 1 millionth of a mho or 1 micromho. High-quality condensed steam, distilled or demineralized water sometimes have specific conductances at room temperature as low as 1 micromho. This would be caused by about one-half ppm. of dissolved salt. Absolutely pure water would have a conductance of about 0.05 micromhos at 25 C.

The mechanism of electrolytic conduction differs from that of metals. In the latter, current is carried by free electrons; in the former, current is carried by ions only. Electrolytic conductivity is non-specific in that all ions present in a solution contribute to the overall conductance. This is in marked contrast to the general lack of influence of other ions on a pH measurement which, over most of its useful range, is responsive to the H-ion concentration alone. The equipment and the methods used for measuring conductivity and pH are entirely different. Conductivity measurement usually involve determination of resistance by an a-c. Wheatstone bridge; pH measurements requires determination of a d-c. potential difference, using a potentiometer circuit or a high-impedance vacuum-tube voltmeter.

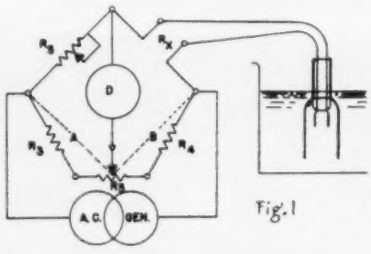

Fig. 1

The Measuring Circuit

The determination of conductivity consists basically in measuring the resistance of a column of solution. Alternating current is almost universally used in order to avoid changes in the composition of the solution adjacent to the electrodes—which effect comes under the general name of polarization. Although other measuring systems are in use, the a-c. Wheatstone bridge is most widely used at present and is potentially the most sensitive, stable and accurate. A typical system consists of three elements; an a-c. Wheatstone bridge circuit, a primary element or conductivity cell, and a null-balance indicator with or without a rebalancing mechanism.

Such a system is shown in Fig. 1. D represents an a-c. voltage-sensitive device as an a-c. galvanometer, ear phone, cathode ray oscilloscope, or an electron ray "tuning-eye" tube. The a-c. source may be a low voltage tap on a 60-cycle transformer, an a-c. hummer, a vacuum-tube oscillator for higher frequencies, a dry-cell-operated vibrator, or other devices. The voltage varies among instruments for differing degrees of accuracy and sensitivity from several millivolts to 50 or 100 volts. The magnitude of the bridge voltage necessarily is related to the sensitivity of the detector and also to the general characteristics of the electrolytes to be tested. For example, in working with living tissues an extremely low bridge voltage is generally required. The usual industrial measuring and control equipment is supplied with bridge voltages in the neighborhood of 1 to 10 volts. The frequency of this a-c. source in commercial units is commonly 60 and more rarely 1000 cps. Where measurements are to be made on high-resistance electrolytes such as distilled water or steam condensate, the lower bridge source frequently is preferable. For measurements in high-conductivity solutions the higher bridge frequency is sometimes of advantage.

R_s is the so-called standard arm of the bridge and is generally made variable, either as a device to change the range of the instrument by selecting one of a number of resistors differing in resistance by powers of 10, or to correct for the temperature coefficient of resistance of the electrolyte. This coefficient for a great many electrolytes has the form

$$R_o/R_t = 1 + at + bt^2$$

An equation of this sort can frequently (but with a number of notable exceptions) be set up to hold within 1 or 2 percent over moderate concentration and temperature bands. For NaCl the value of a, referred to 18 C., is 0.241/C and this agrees with the measured values with relatively small error from extremely dilute solutions to saturation, and from 0 to 100 C.

R_3 and R_4 are end resistors whose function is to establish the limits of the bridge calibration. R_3 is the calibrated slide wire potentiometer. With R_3 and R_4 short circuited, the range of the bridge would be from zero to infinity in resistance or conductance. Increasing values of R_3 and R_4 compared with the value of R_3 will reduce the range covered. It should be noted that the slide-wire contact resistance does not enter into the arms of the bridge and thus variable values of this resistance cause no error in bridge readings.

R_x is effectively the resistance of the electrolyte measured between the two electrodes of the conductivity cell immersed in the liquid under test. A condition of balance of the Wheatstone bridge is that A/B shall equal R_s/R_x; and this condition is indicated by no current flow through the detector, "D."

The Conductivity Cell

The conductivity cell is simple in basic structure, consisting typically of two metal plates or electrodes firmly

*Presented at Symposium on pH and Conductivity, New Jersey Section, Instrument Society of America, April 4, 1950.

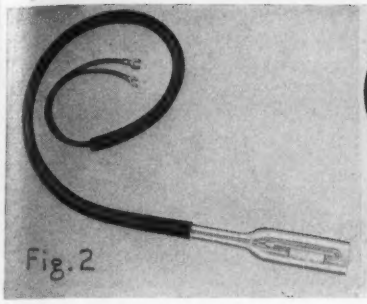
Fig. 2

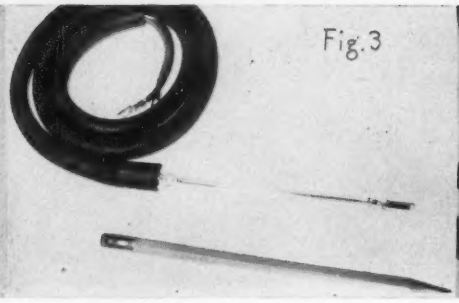
Fig. 3

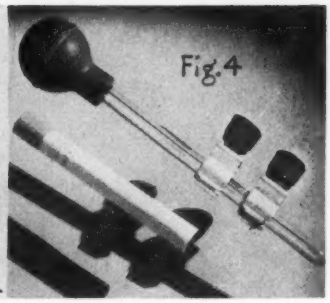
Fig. 4

spaced within an insulating chamber which serves to isolate a portion of the liquid. This arrangement makes the measured resistance independent of both sample volume and closeness to conductive surfaces like tank walls and metal piping. The electrodes are almost always coated with a deposit of spongy black platinum which, by increasing greatly the effective surface, reduces the polarizing effect of the passage of current between the electrodes. The coating of platinum black is easily deposited and is quite resistant to mechanical removal. It is not at all affected by materials which will poison platinum-hydrogen electrodes used for pH measurements, nor does it deteriorate on drying.

Specification of a conductivity cell for most applications may be made on the basis of the service requirements under three headings: electrical, chemical, and mechanical.

Electrical: Experience has shown that the practical limits of measured electrolytic resistance for reasonable accuracy and sensitivity are about 50 ohms and 100,000 ohms. The first requirement then is to select a conductivity cell of such cell constant that the measured resistance of the solution under test will fall within these limits. A cell of low cell constant as 1/10 will have large plates close together and would be used in the measurement of high-resistance or low-conductance solutions, as distilled water. Spreading the plates apart and constricting the electrolyte cross-section increases the cell constant. Constants from 0.01 to 100 are generally available in both industrial and laboratory conductivity cells. Usual values for most applications range between 0.10 and 2.0. For highly conductive solutions, for example, 20 percent HCl at 18 C., the measured resistance with a cell of constant 100 would be 135 ohms. By contrast, a cell of constant 1.0 would have a measured resistance of only 1.35 ohms. The accurate measurement of so low an electrolytic resistance as this would be difficult and would require special equipment.

Chemical: The requirement of resistance to chemical action is always present, and a conductivity cell constructed of suitably resistant materials must be chosen. The problem is occasionally complicated by the fact that a-c. potentials are imposed on the electrode materials. An example showing the need for considering this factor is the case of measurements in strong commercial hydrochloric acid. Although platinum is considered resistant for this service, electrodes of this metal with 5 or 6 volts of 60-cycle a.c. across them slowly dissolve. For this application tantalum electrodes have also proved to be unsatisfactory, but for the reason that an insulating film is formed. Graphite electrodes appear to be quite suitable in this case.

Laboratory conductivity cells traditionally have been made of glass with electrodes of platinum. For many years conductivity cells for plant use were minor adaptations of the same cells. High cost, fragility, the need for cautious and gentle handling and the usual operator's inherent distrust of glass objects, were deterrents to their widespread usefulness. In recent years, more sturdy construction, and the employment of other materials, including plastics, in industrial conductivity cells, have gone far in eliminating earlier shortcomings.

Mechanical: Under mechanical requirements are included the other service considerations which have an important bearing on the proper choice of conductivity cell. These include the factors of temperature, pressure, and physical state. The usual service limitations of pyrex glass conductivity cells is in the vicinity of 50 psi. pressure and 300 F. Where operating limits are above either of these values, it is common practice to draw a continuous small sample of the liquid through a sample cooler of adequate rating to cool and condense the sample, then through a throttling valve to reduce the pressure and only then to bring the sample in contact with the conductivity cell. Sample-cooler and cell-holder assemblies of various pressure ratings and throughout capacities are commercially available and two of these are illustrated in Fig. 1.

The insertion type of conductivity cell incorporating a gate valve through which the element may be drawn is advantageous in many situations where it would not be convenient or possible to empty the line when removing or inspecting the conductivity cell. Insertion cells have been built for service up to and beyond 300 psi. at 250 F. Conductivity cells made of polystyrene are commonly used for spot testing both condensed steam and boiler water samples. However, on account of its rather low upper safe temperature limit, it would be unwise to mount a polystyrene cell in a continuously-cooled flowing sample on account of the ever-present possibility of overheating and deforming it, should the cooling water supply fail even momentarily. Deformation would be more likely to cause a permanent change in the cell constant rather than to make it completely inoperative. The result would then be continued erroneous readings without clear warning of trouble.

In the next group of figures are shown a variety of conductivity cells, some designed for laboratory work and other specifically for industrial service. Fig. 2 is a widely-used laboratory dip cell of Pyrex construction with platinum electrodes and a cell constant of unity—adjusted in manufacture to within 1 percent of nominal. It requires 4-inch immersion and a sample volume of at least 200 c.c. A cell of

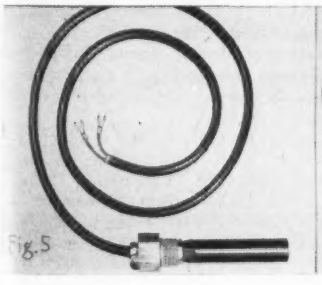
Fig. 5

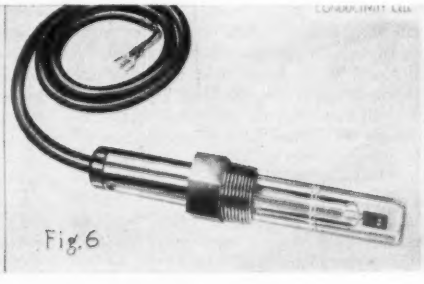
Fig. 6

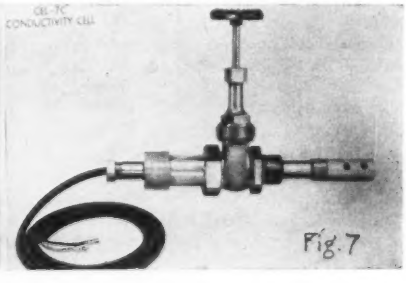
Fig. 7

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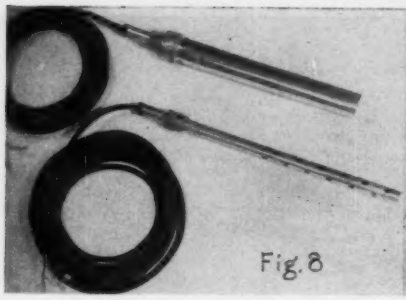
Fig. 8

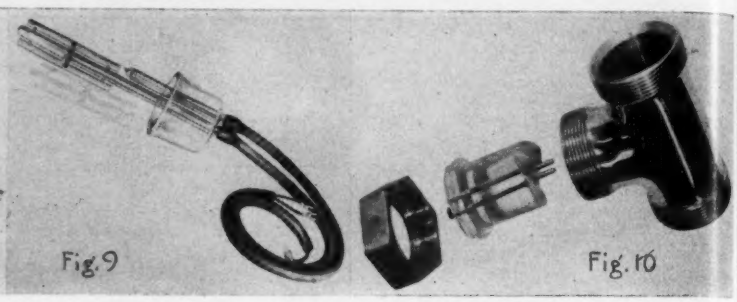
Fig. 9

Fig. 10

lower cell constant and smaller dimensions is shown in Fig. 3. With a constant of 1/10, this cell is only a quarter-inch wide. Fig. 4 shows a pipette cell with a constant of 100 and capacity of only 0.02 cc. Fig. 5 is an industrial cell of molded or neoprene with platinized nickel electrodes and available over quite a range of cell constants. It is provided with a three-quarter-inch threaded stainless steel fitting for pipe-line or tank installations for service up to 220 F. and 50 psi. Fig. 6 is a screw-in cell of heavy walled Pyrex construction with platinum electrodes and suitable for operation up to 250 F. and 50 psi.

An old and popular type of conductivity cell, shown in Fig. 7, has the great advantage of permitting removal under operating conditions without the necessity of draining the line or tank. After slightly loosening the packing gland at the cable end, the element is drawn through the normally-opened inch-and-a-quarter gate valve and reaches a stop, whereupon the gate valve is closed by hand and the element removed for inspection or repair. Insertion cells of this type have been built for operation at 300 psi. and 250 F. Cells of this construction are usually supplied in bronze or brass but are also available in stainless steel and teflon for service in highly corrosive media. Electrodes are usually gold- or platinum-plated, and the insulating section may be Bakelite, ceramic or Teflon. Cells with constants from 0.01 to 2 are available at present in this construction.

The pair of cells shown in Fig. 8 illustrate one way of improving the strength characteristics of a glass assembly. The wider unit containing the measuring cell of heavy-walled Pyrex has a cell constant of 20. The long narrow unit contains a filled-glass reference conductivity cell, and serves as an automatic temperature compensator. Shields and fittings are of Carpenter No. 20. The cells were used in the control of hot strong sulfuric acid. Fig. 9 shows a cell and temperature compensator built into a standard Pyrex flange for service in a 3-inch glass pipe line, carrying a highly conductive liquid.

The cell shown in Fig. 10 is designed for use in sanitary piping systems, particularly milk lines. The shape of the cell is such that its surface conforms to the radius of the pipe and offers little obstruction to flow. Fig. 11 also shows a cell designed for service in sanitary milk lines, particularly in connection with timing the flow of short-time high-temperature pasteurizers. Two identical cells are mounted in tees in the piping at inlet and outlet ends of the holding tube. With water being pumped through the system, a small volume of saturated salt solution is injected through the nozzle of the upstream cell—this will unbalance a Wheatstone bridge connected with this first cell. A stopwatch is started, and the downstream cell is switched into the bridge. When the salt front reaches this cell, the conductivity bridge detects the change and the stopwatch is stopped. The elapsed time is taken as the holding time and the pump either reset or sealed.

Fig. 12 illustrates a glass flow type cell in a hinged steel case. A high-pressure conductivity cell is shown in Fig. 13. In all-stainless-steel construction, with a ceramic insulator and lead gaskets and Teflon shield, this construction is suitable for 500 psi at elevated temperatures.

Where there is a strong tendency for solids to deposit out of a liquid, as for example, in a starch suspension or gypsum slurry, the usual type of cell construction with platinized platinum electrodes inside an insulating sheath presents great operating difficulties. For such service, a conductivity cell without the insulating chamber and with large flush unplatinized electrodes is useful. The tendency for solids to deposit on a smooth surface which is exposed to rapidly-moving liquid is greatly lessened. Also, it is much easier to remove mechanically the deposit if this does occur. The materials of construction of this particular cell, shown in Fig. 14, are bright platinum rings embedded in plastic. With unplatinized electrodes it is usually impossible, even in moderately-conductive solutions, to obtain a sharp bridge balance on account of polarization.

There are several ways to improve this condition. One is to use a reference cell in the standard arm of the Wheatstone bridge of the same type of construction, immersed in a similar solution of known composition. This can be combined with automatic temperature compensation by subjecting this reference cell chamber to the same temperature as the liquid under measurement. A second device is to use a wire-wound standard resistor with a capacitor in parallel so as to correct for the phase angle shift. A proper value of the parallel capacitance can most readily be determined by trial and error.

Fig. 15 and 16 illustrate two types of sample coolers used chiefly for measurements on boiler water and steam. The ratings are respectively 600 psi. and 150 psi. saturated steam. Both coolers are provided with fittings to accommodate standard flow type conductivity cells.

Properties of Conducting Solutions

Turning now from the measuring devices to the properties of conducting solutions, it is of interest to examine several typical conductivity-concentration curves. A plot of the specific conductance of most electrolytes as a function of concentration in water at constant temperature starts almost linearly, rising with concentration and gradually decreasing in rate until a maximum is reached, usually at about 20 percent by weight, then falling off as the concentration rises further. The temperature coefficient of conductance of electrolytes is much greater in magnitude and opposite in direction to that of metals; i.e., as the temperature rises the conductance of the solution rises. The coefficient generally is about 2 or 3 percent per centigrade degree of the conductance at 18 or 25 C. Figs. 17 to 20 show the relationship for several common electrolytes between specific conductance, concentration and temperature.

NaCl. Sodium chloride solutions saturate before the conductivity maximum is reached. It may be seen that the conductance rises continuously with both concentration and temperature. The alkali metals (except lithium) and ammonium halides, sulphates and nitrates exhibit no maxima in their conductance-concentration curves.

HCl. Hydrochloric acid exhibits maxima in its conductivity curves at quite close to the same concentration over the entire range of 0 to 65 C. This uniformity is not very common. At concentrations above 20 percent, the conductance diminishes as the concentration rises. This does not detract from the possibility of utilizing this function in measurement and control. The concentration of strong commercial hydrochloric acid can readily be checked even though its specific conductance falls on the down slope.

NaOH. The shift of the conductivity maximum with temperature is very marked, changing from about 15 percent at 18 C. to almost 30 percent at 100 C. Where it is desirable to measure or control NaOH concentrations in the vicinity of 15 or 20 percent, it is evi-

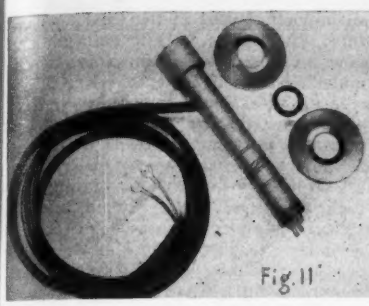
Fig. 11

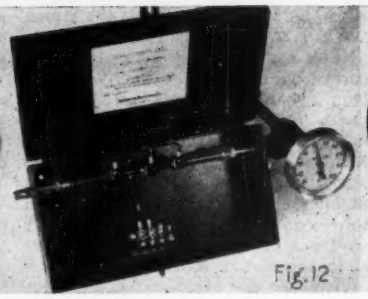
Fig. 12

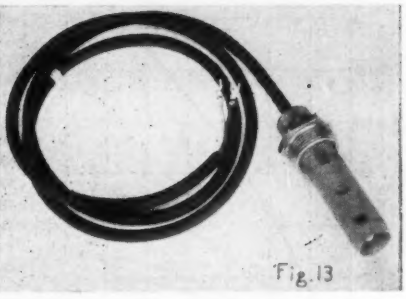
Fig. 13

dent that conductivity offers little in the region of 18 C. If, however, the sample of caustic is run through a small heat exchanger and warmed to 100 C., accurate measurements and control by conductance become practicable.

$CaCl_2$. Calcium chloride exhibits the behavior characteristic of most salts, in that there is a maximum between concentrations of 20 and 30 percent which shifts in the direction of higher concentration as the temperature rises.

These curves, illustrating importance differences as well as the basis similarities in the conductance behavior of various electrolytes, point up the need for and the value of relatively complete data on all of the common electrolytes.

Scarcely a generalization regarding the conductance behavior of electrolytes can be made without important exceptions. We have seen that the specific conductance rises with increasing concentration of electrolyte and that after 20 or 30 percent the conductivity falls off. For some electrolytes particularly the polybasic strong acids, such as sulphuric and phosphoric acid, there are multiple inflection points at high concentrations. All of the curves shown have exhibited a rise in conductance with temperature at fixed concentration. Although I am aware of no exceptions to this in solutions of single electrolytes below 100 C., at higher temperatures, many electrolytes do have a maximum and a minimum in the conductivity-temperature curve.

In solutions as dilute as 10 or 20 ppm., addition of a second non-reacting electrolyte will increase the conductance to an almost exactly additive extent.

Fig. 14

At somewhat higher concentrations the addition of a second electrolyte will increase the conductance, but the effect will be only approximately additive although calculable rather simply from a general equation. At very high concentrations the relationships are quite specific and sometimes even reversed. For example, addition of ferrous sulphate to sulphuric acid will decrease the conductance of the solution.

Applications

There are many applications where conductance measurements have become standard tools. Those discussed below are several typical and widespread uses.

Boiler Operation.

(a) Steam Purity.—Conductance measurement is today the most common means of continuous steam purity determination. Clean steam, free from entrained boiler water solids, is important in all boiler operations but particularly in high-pressure boilers with superheaters and turbines, and whatever boiler steam is introduced directly into kettles or reactors for heating pure materials. The steam must be sampled properly, cooled, condensed and its pressure reduced to atmospheric before coming in contact with the conductivity cell.

(b) Feedwater.—Regardless of the source of the feedwater, it is desirable that increases in solids content of the water going into the boiler be recognized just as quickly as possible and corrected if feasible or, if unavoidable, be compensated for by alteration in feedwater treatment. Probably the widest use of conductivity meters is in the detection of leakage of conducting liquids into steam condensate. Common sampling points for the measurement of the purity of return condensate are the condenser hotwell or the line after the hotwell pump. The insertion type of cell based on the 1-¼ inch gate valve and removal device is widely used here. Instrument ranges of 0-10 or 0-50 micromhos are adequate.

(c) Boiler Blowdown.—The third field of service of conductance equipment is in the testing of boiler water itself. In recent years, the practice of regulating blowdown on the basis of interrelationship among the analytically-determined ions and salts in the boiler water has yielded to control by determination of total dissolved solids content with less emphasis on individual constituents. Control of the total dissolved solids content of boiler water is recognized to be a factor of major importance in maintaining high steam purity and clean heat-exchange surfaces. Higher boiler solids are always associated with an increased tendency to carry over with the steam. Control of the boiler-water-dissolved solids just below the critical value at which steam purity is adversely affected is a basic requisite for proper boiler operation. Conductance values have been found to correlate closely with total dissolved solids of most boiler waters. The boiler water sample is continuously drawn from a point about mid-level of the drum and as distant as possible from the entrance points of feed-water. The sample is cooled and its pressure reduced to atmospheric before flowing past the conductivity cell. By measuring boiler water conductivity it is usually possible to detect in advance of an indication by the steam purity recorder, an upset or variation in feedwater treatment or blowdown control.

Exhaustion of Caustic in Scrubbing Towers.

A well-developed application is the measurement of caustic soda or potash scrubbing tower solutions which are used to remove carbon dioxide from air or hydrogen prior to compression. Starting with a sodium hydroxide solution of any given strength, complete conversion to sodium carbonate constitutes 100 percent exhaustion of the solution. By plotting specific conductance against equivalent concentration for both sodium hydroxide and sodium carbonate, two curves are obtained, the former having the higher conductance at all concentrations. At equal equivalent concentrations the difference between the conductivities may be taken directly from the graphs and this represents the drop in conductance cor-

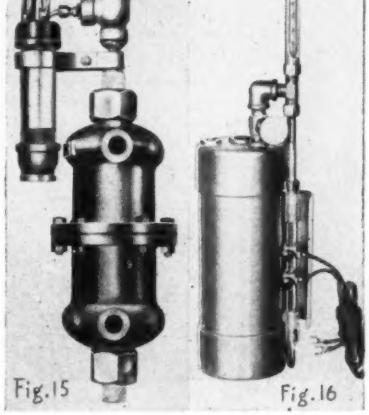
Fig. 15

Fig. 16

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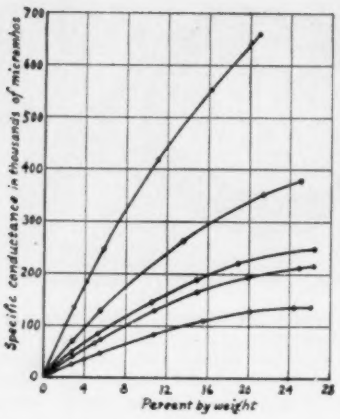

Fig. 17

responding to 100 percent exhaustion of the tower solution. Intermediate values of the conductance decrement correspond to partial exhaustion. This system is easily calibrated either graphically or empirically. Fig. 21 is a typical graph relating conductivity to percent NaOH remaining of an initial 15 percent NaOH solution. This technique of relating conductance differences, rather than absolute conductance values, to concentration or extent of reaction has been applied to relatively few processes in industry. However, this method is broadly applicable to electrolytic reactions and in many cases is one of the few possible methods of continuous instrumental analysis of a reacting system.

Condensate Contamination

Where process steam, used for heating tanks or kettles internally through coils or externally through jackets, is condensed and returned to the boiler as feedwater, there is always present the danger of leakage of tank contents into the steam line and so into the boiler. The consequences of this, in many chemical, plating and pharmaceutical plants are so serious that countless millions of gallons of good quality condensate are yearly run into the sewer rather than risk the return of contaminated condensate to the boiler. Here too, periodic chemical analysis of return condensate samples is at best an inadequate safeguard. At worst, such analysis may be misleading. A small break in the jacket for example may permit no leakage when the steam pressure is up, and yet, when the steam valve is closed and the pressure drops, the tank contents may be drawn into the return line to enter the feedwater system when the steam valve is reopened. Chemical analysis during the time when the steam pressure was up would give no hint of the impending trouble. A condensate conductivity controller or recorder with high alarm contacts would immediately detect the first trace of excess conductive material in the return and warn the operator. Where the tank contents are organic in nature and do not form conducting solutions in water, this method of course is not applicable.

Acid Cooling Tower Condenser Leakage.

A conductivity controller or recorder provided with a high conductivity alarm switch, and a cell located in the output end of the cooling water system, provides a direct means of protecting the piping and the circulating system against the effects of acid leakage. In cases where the cooling water may vary widely in total dissolved solids, it is advisable to mount an additional conductivity cell in the input end and utilize a bridge which measures the difference in conductivity between output and input, which difference is a function of pick-up of electrolyte in the tower.

Plant Wastes.

In operations where wastes are largely electrolytic in nature, conductivity measurements may provide a simple index to their concentration and offer, at the same time, the attractive possibility of continuous measurement and recording. In addition to its measurement fluctuation, such equipment has been successfully applied in a large metal works to control rinse water, after a dichromate brightening dip. Not only was a significant saving effected in the quantity of water used but the plant waste treatment system was spared the burden of handling this excess and useless gallonage. The control equipment used consisted of a conductivity cell in the drain and a conductivity recorder with adjustable high and low contact switches operating a motor-driven valve in the fresh-water line.

Irrigation Water.

In certain low areas along the coast of the United States, irrigation plays an important part in the local agriculture. In periods of low rainfall, the flow of fresh-water streams is diminished to such an extent by the increased diversion for irrigation, that sea water is drawn upstream and enters the pumping system. Continued for any appreciable period, this influx of salt can cause serious damage to both crop and soil. Simple conductivity equipment has been effectively used here to signal any significant increase in salinity of the pump intake. Similar equipment is rather widely used to detect salting of fresh water wells, to locate salt leaks in deep well casings, and to locate the interface between salt and fresh water in regions such as Bermuda where the fresh water floats on the salt and the water table is subject to wide fluctuations.

Distilled and Demineralized Water.

One of the earliest industrial applications, as well one of the largest fields of current service of conductivity equipment, is the measurement of the purity of refined waters—as condensed steam, distilled water and demineralized or deionized water. Such water ordinarily contains about 1 ppm of dissolved salts and sometimes considerably less. Even a simple and inexpensive bridge can measure the resulting conductivity amounting to 2 micromhos with an accuracy of 5 percent or about 1/20 ppm. A flow type cell installed permanently in the line is much to be preferred to a dip type cell for occasional immersion in a small volume of test solution. The danger of contamination (and resultant higher conductivity reading) is always present in a sampling procedure. A conductivity controller with high alarm switch wired to a solenoid or motorized valve and to a remote signal provides a most reliable means of obtaining optimum throughput from a two-bed ion exchanger by signalling the break-through point and initiating the regeneration step.

Concentration Control.

The problem of measuring and maintaining the concentration of solutions of single acids, bases or salts is widespread and the use of conductivity equipment for this purpose is in many instances quite general. This method is useful over the whole range of concentration from just slightly contaminated distilled water to saturation,

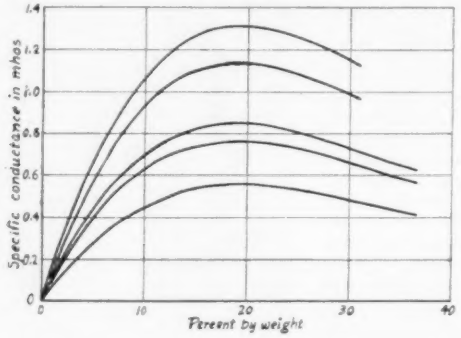

Fig. 18 (left)

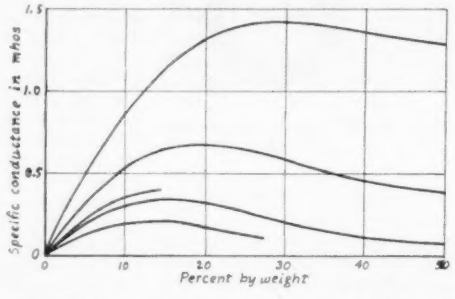

Fig. 19 (right)

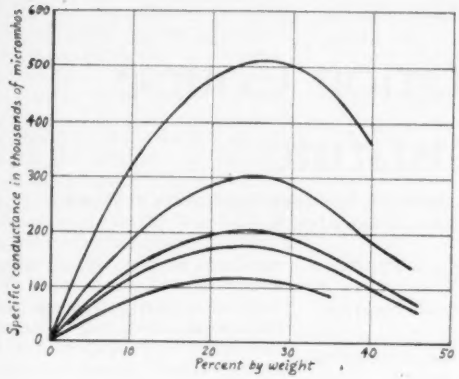

Fig. 20

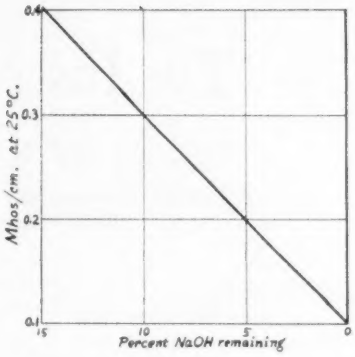

Fig. 21

with, however, the limitation imposed by inflection points and the shape of the conductivity-concentration curve. The usual alternative methods of measurements are either chemical analysis or specific gravity.

A list of specific use of conductivity equipment in this catagory would be very long. Examples include the following:

Caustic fruit peeling baths	—	3-20 percent NaOH
Pea grading baths	—	10 percent NaCl
Anodizing solutions	—	10-20 percent H_2SO_4
Chromium plating	—	10-20 percent CrO_3

Completeness of Washing and Rinsing.

The possibilities of effective use of conductivity measurements in this field are numberless. Whenever an organic or relatively insoluble inorganic material must be washed free of electrolytes (and this is a very common and frequently performed operation) some index of completeness of removal of contaminant is necessary. Too much washing wastes time, power, water and filter cake. Too little washing does not sufficiently remove impurities. The washwater conductivity is an excellent measure of the amount of electrolytic material remaining in the cake. A recording of the washwater conductivity indicates in a graphic manner the details of the complete filtration and washing cycle, and the record serves further in the analysis of earlier process variables. Fig. 22 is a 24-hour chart of a centrifuging operation. The recorder is calibrated in ohms specific resistance. When a fresh batch is started up in the centrifuge, the washwater is initially high in salts and the pen is close to the origin. As washing with fresh water commences and continues, the resistance rises until the pen reaches about 30 on the chart, at which point an alarm contact makes, cuts off the fresh water supply and signals the operator. In one installation, rejects on the basis of excessive salt content, dropped from 45 percent to 5 percent several weeks after these instruments were installed.

The same method of testing for electrolytic impurities by measuring the rinse water conductivity has been applied in the manufacture of paper intended for use as electrical insulation, in the removal of dyestuffs from cotton thread used for insulation, and in numerous operations in the textile industry.

Gas Analysis.

Although not usually though of in connection with gas analysis, electrolytic conductance equipment has been used and is being used quite generally for the measurement of certain gaseous materials. Most of the work done in recent years in connection with atmospheric pollution by SO_2 has been carried out conductometrically. Concentrations as low as several parts per billion can be measured with accuracy using a batch absorption technique. Other acidic gases as H_2S, CO_2, Cl_2 can be determined accurately in very low concentrations by the change in conductance of a fixed volume of a suitable absorbant solution, as $Ba(OH)_2$ in the case of CO_2, after passage of a known volume of the contaminated air. Similarly, free ammonia in a stream of hydrogen or other non-reactive gas can be determined either by absorption in a stream of dilute acid or distilled water using flows in fixed proportion. Halogenated hydrocarbons such as methyl bromide, carbon tetrachloride, etc. in air are measured in the same way by heating the stream of air to decompose the vapor to the halogen acid as HBr or HC1 respectively and absorbing the product in a metered flow of distilled water and measuring the conductance. Such equipment can be calibrated directly in terms of ppm. of the contaminant.

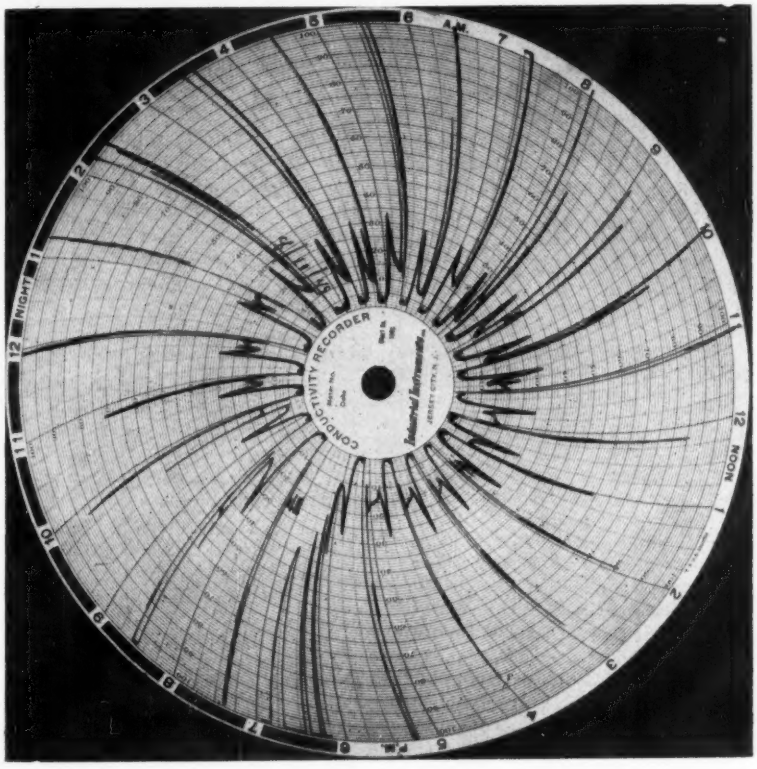

Fig. 22

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The Instrumentation Course *at* Pratt Institute

By E. P. LAMBE, Professor, and D. S. DUNCAN, Assistant Professor, Department of Physics,
School of Engineering, Pratt Institute, Brooklyn, N. Y.

PART I

DESCRIPTIVE

THE course described below had its genesis in 1938 under the name of "Measurements and Standardization." No text books on Instrumentation were available at that time (except Behar's "Manual of Instrumentation" which was unfortunately out of print.) Emphasis at first was placed upon the measurement of physical magnitudes and upon standardization methods. Even in the first years, however, some attention was given to modes and characteristics of modes of control. The evolution of the course has continually been in the direction of industrial instrumentation.

The present course, Instruments and Control, concerns itself with the measurement and control of those variables ordinarily associated with the field of industrial process control. It involves a study of:—

1. The basis for the units used in common industrial measurements. (Pressure, temperature and speed.)

2. Methods of measuring these; and of standardization technique.

3. The theory of automatic control particularly as related to process control.

4. Typical indicating, recording and controlling instruments.

An outline of the course follows:

Texts: "Industrial Instruments for Measurement and Control" by Rhodes; "Pyrometric Practice T-170"—Bureau of Standards.

References: "Principles of Industrial Process Control" by Eckman; "Manual of Instrumentation" by Behar in *Instruments*; "Pyrometry" by Wood and Cork; "Heat and Temperature Measurement" by Weber; "Experimental Mechanical Engineering" by Diederichs and Andrae; "Telemetering" by Borden; Trade Publications.

The course is given for 16 weeks (including examinations) with two hours a week laboratory.

CLASSROOM SCHEDULE

Week

1. Discussion of outline and objectives of course. Thermodynamic and International Temperature Scales.

2. Measurement of emf. by millivoltmeter and potentiometer. Primary and secondary standardization.

3. Thermocouple theory. Materials used: cold junction compensation and correction.

4. Resistance thermometers. Circuits.

5. Thermometry. Liquid in glass. Range. Immersion depth. Thermostats. Bimetallic helix thermometers. Pressure bulb thermometers. Principles of operation. Thermometric lag.

6. Optical and Radiation Pyrometer. Principles, method of calibration, sources of error, range, applications.

7. Automatic Control Theory, Terminology, Elements of an automatically-controlled system.

8. Modes of control and their characteristics.

9. Analysis of an automatically-controlled system with laboratory demonstration.

10. Discussion of typical control problems and appropriate modes of control.

11. Discussion of typical mechanisms for indicating, recording and control.

12. Pressure Measurements. Manometers, gages, bellows; bells.

13. Rate-of-flow measurements. Primary elements. Inferential type meters.

14. Telemetering.

15. Student papers.

16. Final examination.

Several quizzes are given during the semester. A notebook is required. Each student prepares a paper and makes an oral report on some industrial instrument. Liberal use is made of manufacturers' catalogs and bulletins. Slide and opaque projections are used extensively.

LABORATORY SCHEDULE

The following exercises are given:

1. Measurement of emf. by millivoltmeter and potentiometer.

2. Primary standardization of a noble-metal thermocouple.

3. Secondary standardization of a base-metal thermocouple.

4. Primary standardization of a platinum resistance thermometer.

5. Calibration of an optical pyrometer.

6. Calibration of a total radiation pyrometer.

7. Study and calibration of speed-measuring instruments.

8. Determination of lag coefficients of various types of temperature-measuring instruments.

9. Study of students' type and type K Potentiometers.

10 & 11. Demonstration and study of an automatically controlled liquid level system.

12 & 13. Demonstration and study of an automatically controlled flow system.

In the development of this course, the lack of a suitable text seemed a handicap, at first. It now appears that it may have been a blessing. The necessity of exploring a large number of references, including manufacturers' literature, has resulted in a better-informed faculty, and has led to the adoption of the present distribution of topics and hours.

At no time has a departure been made from the original premise: that above all, the engineer should know the fundamentals of measurement and standardization. However, owing to time limitations, as the emphasis upon automatic control has increased, it has been necessary to limit the coverage to temperature, pressure, flow and speed.

In both the classroom and laboratory, instruction is based upon standard methods and standard instruments. For example, as far as it is feasible in the allotted time, the methods laid down by the Bureau of Standards are followed in the primary standardization of a noble-metal thermocouple, and of a platinum resistance thermometer. Great effort is made to impress the student with the over-all requirements for accuracy, including calibrated instruments and proper installations.

As one feature of the course, each student is required to prepare a short paper upon some industrial instrument. He obtains his information from a file of instrument manufacturers' catalogs maintained in the department, and from direct correspondence with manufacturers. He is allowed ten to fifteen minutes to summarize his paper before the class. He may use a projector if he desires. The end result is the exposure of all the students to a considerable variety of products of instrument manufacturers.

The students are encouraged to subscribe to *Instruments* and to become student members of the local branch of the I.S.A.

PART II

EQUIPMENT FOR DEMONSTRATION OF AUTOMATIC CONTROL

The teaching of the theory of automatic process control presented considerable difficulty. The available texts were not suited to our purposes. The terminology has been in a state of flux. Also, the students had great difficulty in visualizing such things as proportional band and reset. Accordingly, the apparatus described herein was designed and built.

The objectives were two-fold. First, a visual aid to the understanding of the terminology. Second, a system to which various modes of control could

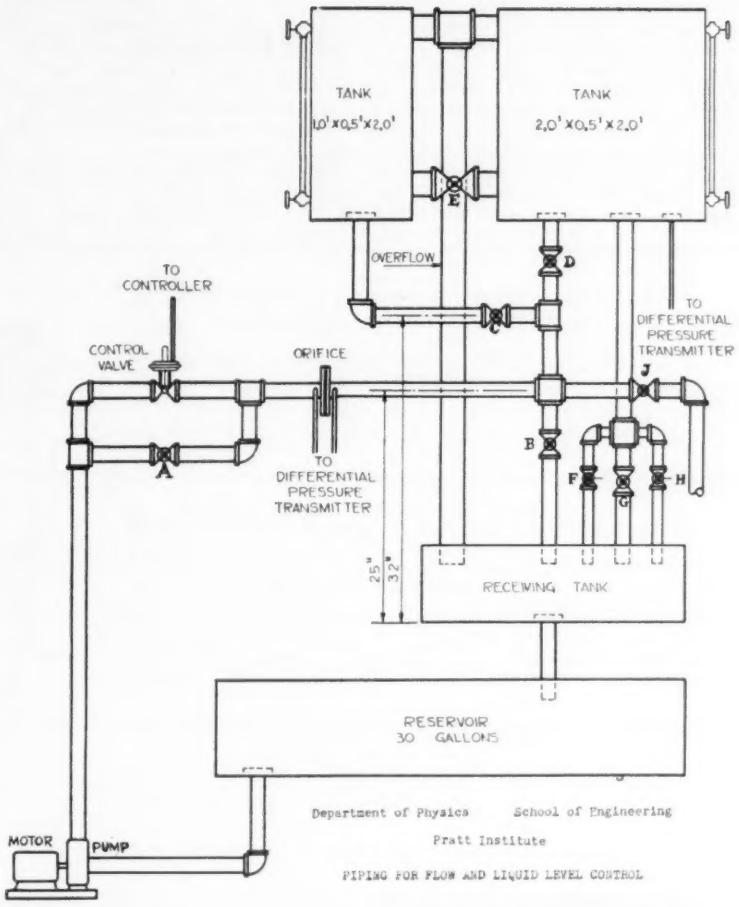
be applied and the effects of these modes on the operating characteristics of the system observed.

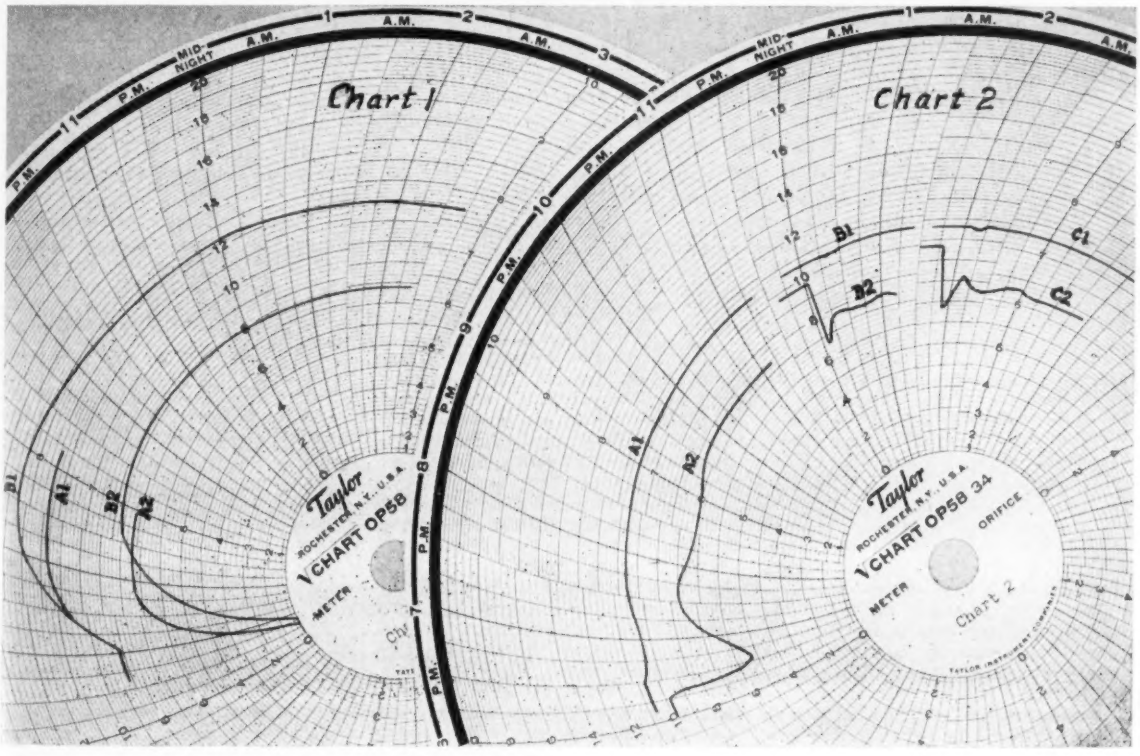
It was decided that commercially-available equipment should be used wherever possible so that a by-product of this apparatus would be the understanding by the students of the operation of the instruments of at least one manufacturer. The control equipment selected, made by the Moore Products Company of Philadelphia, seemed best *for demonstration purposes*, because such elements as pressure transmitter, set point regulator, controller and derivative units were separate. By this choice it was hoped that the students could more easily obtain an understanding of the function and operation of each part of the instruments.

A flexible apparatus was desired. The goal was to be able to demonstrate a single-capacity process and a multi-capacity one; a fast-responding process and one which was slow; one which was easy to control and another which was more difficult. Flow control was picked as the prototype of a fast process and liquid level was selected to illustrate the other types.

The authors wish to extend due credit for ideas contributed in connection with this set-up, to the Foxboro Company, to the Bristol Company and to the Moore Products Company.

The accompanying piping diagram is almost self-explanatory. The centrifugal pump draws water from the reservoir and, under normal operation, sends all of it through the air-operated control valve. The by-pass (A) around this is manually-operated and is kept closed while liquid level is being studied





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but is used to obtain a variation of load under flow control. When this is the case, the water is discharged, after passing through the orifice, through the cross and valve B to the receiving tank and then re-circulated.

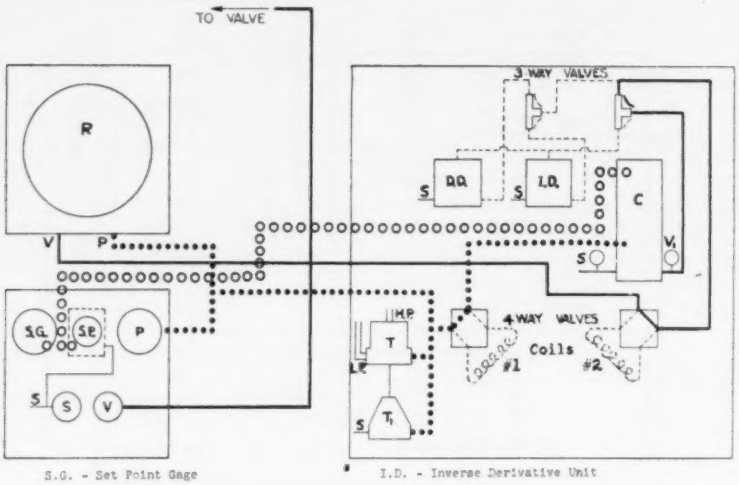
When studying a single-capacity process, all manually-operated valves are closed except D, to permit the water to enter the large tank; and F, G, and H which are used to vary the load. To convert this to a two-capacity system, valve D is closed, C opened wide, and E opened partly to produce the desired restriction between the two tanks. Thus the flow is through the control valve, small tank, restrictive valve E, large tank and finally the load valves F, G, H back to the reservoir and pump. Of course, in this process, the liquid level in the large tank is the one which is controlled, with the level in the small tank being allowed to take any required value.

The signal produced by the liquid level in the large tank is sent through brass pipe from the bottom of this tank to the High-pressure side of the Differential Pressure Transmitter, the Low-pressure side of which is open to the atmosphere. To switch to flow control, the orifice pressure taps are connected through similar brass pipes to the High- and Low-pressure sides of the Transmitter simply by closing two and opening two other valves.

It should be noted that the system was so designed that the maximum differential pressure at the orifice is approximately equal to the pressure created with maximum liquid level. Thus the same transmitter could be used for both flow and liquid level.

Pratt Institute Department of Physics School of Engineering

INSTRUMENTATION FOR FLOW AND LIQUID LEVEL CONTROL



S.G. - Set Point Gage
S.P. - Set Point Regulator
P - Process Gage (liquid level or flow)
S - Air Supply or Air Supply Gage
C - Controller
D.D. - Direct Derivative Unit
I.D. - Inverse Derivative Unit
R - Recorder
T - Differential Pressure Transmitter
T_1 - Booster Pilot Valve
V - Valve Pressure Gage
V_1 - Pressure Delivered by Controller

Note that V_1 should read the same as V when neither derivative unit is cut in.

H.P. and L.P. are high and low pressure connections respectively to orifice or to tank.

SYMBOL .....
Differential pressure transmitter T receives signal from orifice plate or liquid level, and, with aid of booster pilot valve T_1 transmits amplified signal to P, process gage; R, recorder; and C, controller.

SYMBOL 0000000000
Set point regulator S.P. transmits appropriate signal to controller C. Set point is read on gage S.G.

SYMBOL _____
Controller C transmits signal to valve; to recorder R; and to gage V.

Dashed lines indicate optional connections. 4-way valves afford means of introducing tubing into system to give distance effect. 3-way valves provide means of cutting in either direct derivative unit D.D. or inverse derivative unit I.D.

Recorder is Taylor 2-pen recorder.

Other Instruments made by Moore Products Company.

All of the control instruments except the Set Point Regulator and Recorder, the chart drive of which was speeded up to one half-hour per revolution, are mounted, as shown in the Instrumentation diagram, on a board approximately three feet square. The Controller contains the Proportional Band and Reset Rate adjustments. Either Derivative unit can be cut in or out by manipulation of the 3-way valves.

Also on this board are two coils of quarter-inch copper tubing, approximately 75 feet each, which are inserted in or excluded from the air circuit by the two 4-way valves. These coils were included to simulate actual plant conditions under which the instruments could not be installed directly at the process being controlled. The left coil places all instruments, except the Transmitter and Booster Pilot Valve, at a distance from the process, and the right one places the control valve at a distance from the instruments.

Each student is assigned to this apparatus for four two-hour laboratory periods. During the first two of these, the instructor operates the equipment as a lecture demonstration and the students record the data which are read to them from the chart as the demonstration progresses. It is during the last two of the periods that the students use the apparatus themselves.

The following is a list of some of the things which can be demonstrated with this apparatus:

1. The Set Point can be located at any desired position in the Proportional Band. It is essential to be able to do this when starting up a process or when adding instruments to one which is already in continuous operation.

2. All process characteristics can be observed on the two-pen recorder under (a) start-up, (b) load change and (c) Set Point change, each with any combination of proportional position, reset, direct derivative and inverse derivative action.

3. Droop or Load Error (or "offset") depends on the size of the load change and the width of the proportional band.

4. Either damped or continued cycling is produced by too narrow a band.

5. The optimum proportional band is the narrowest one that does not produce cycling.

6. Under proportional control, droop can be eliminated by moving the Set Point.

7. The addition of automatic reset to proportional action eliminates droop.

8. Too fast a reset rate produces cycling which can be eliminated only by using a slower rate.

9. The optimum reset rate is the fastest one that does not produce cycling.

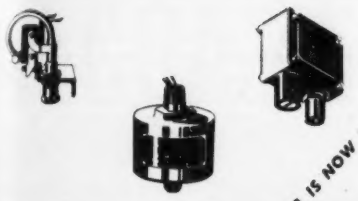
10. Direct Derivative action opposes any change of the measured variable after some upset in the process by causing the control valve pressure to change faster than it would without the use of Direct Derivative.

11. Inverse Derivative can be added to proportional or proportional plus reset action on extremely fast-responding processes to stabilize the measured variable by making the control valve pressure change slower than it would without this Inverse Derivative action.

12. Proportional action produces satisfactory control on a fairly fast-responding process.

13. A slower process needs either proportional plus reset or proportional plus reset plus direct derivative control.

14. By using either or both coils in the air circuit, it can be shown that the optimum instrument settings and the response of the system being controlled



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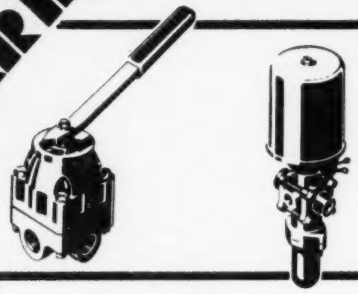

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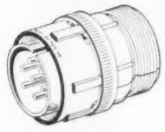

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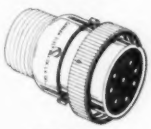

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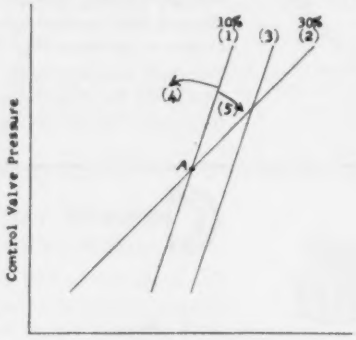
depend not only on that system, but *on the complete closed loop* made up of the process and the control instruments.

15. Geometric interpretations of proportional position, reset, direct derivative, and inverse derivative actions are obtained.

Considerable emphasis is laid on these geometric interpretations of the modes of control. By using only the large tank and either filling or emptying it in steps, data are obtained for curves of control valve position or pressure vs. measured variable (liquid level). By combining this procedure with automatic operation of the process under proportional, proportional plus reset, proportional plus direct derivative, or proportional plus inverse derivative control, it is possible to obtain a set of curves as reproduced which show that: (1) proportional action is represented by any one of these straight lines, (2) a change of band width is analogous to a permanent rotation of the curve around point A, (3) automatic reset action or a manual change of the Set Point shifts the curve parallel to its original position, (4) direct derivative action temporarily rotates the curve counterclockwise about point A (identical with a temporary narrowing of the band), and (5) inverse derivative action produces a temporary clockwise rotation about point A which is identical with a temporary widening of the band.



Curves which interpret various modes of control—obtained by students performing process-control tests with experiment described.

The accompanying charts show some of the results obtained with this apparatus. They are actual records as traced by the recorder.

Chart 1 shows the start-up of a single capacity process under (A) proportional, and (B) proportional plus reset control. The numbers "1" refer to liquid level and the numbers "2" to control valve pressure. The reset rate used was the fastest possible with no cycling, the one which should be used *after* the process is in continuous operation.

Chart 2 compares the optimum responses to load change of the two- and single-capacity systems. Curve A is for the two tanks in series under proportional plus reset plus direct derivative control; B is for the single tank with its optimum instrument settings, and C for the single tank under 1 percent proportional band.

In conclusion, it can be stated that this apparatus has proved completely satisfactory and has done everything that the authors hoped it would do when it was designed. Even though it has been used for only one year, its value as an effective teaching aid is apparent. The students obviously have a much better grasp of the subject than before, and their interest has been greatly stimulated.

ED. NOTE.—For these charts, please turn back to page 671.

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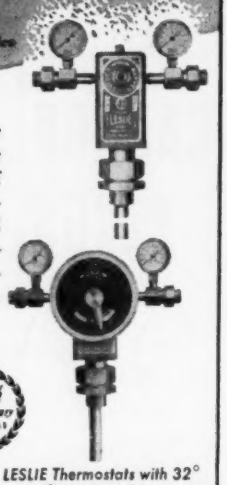

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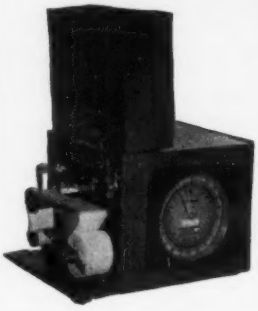

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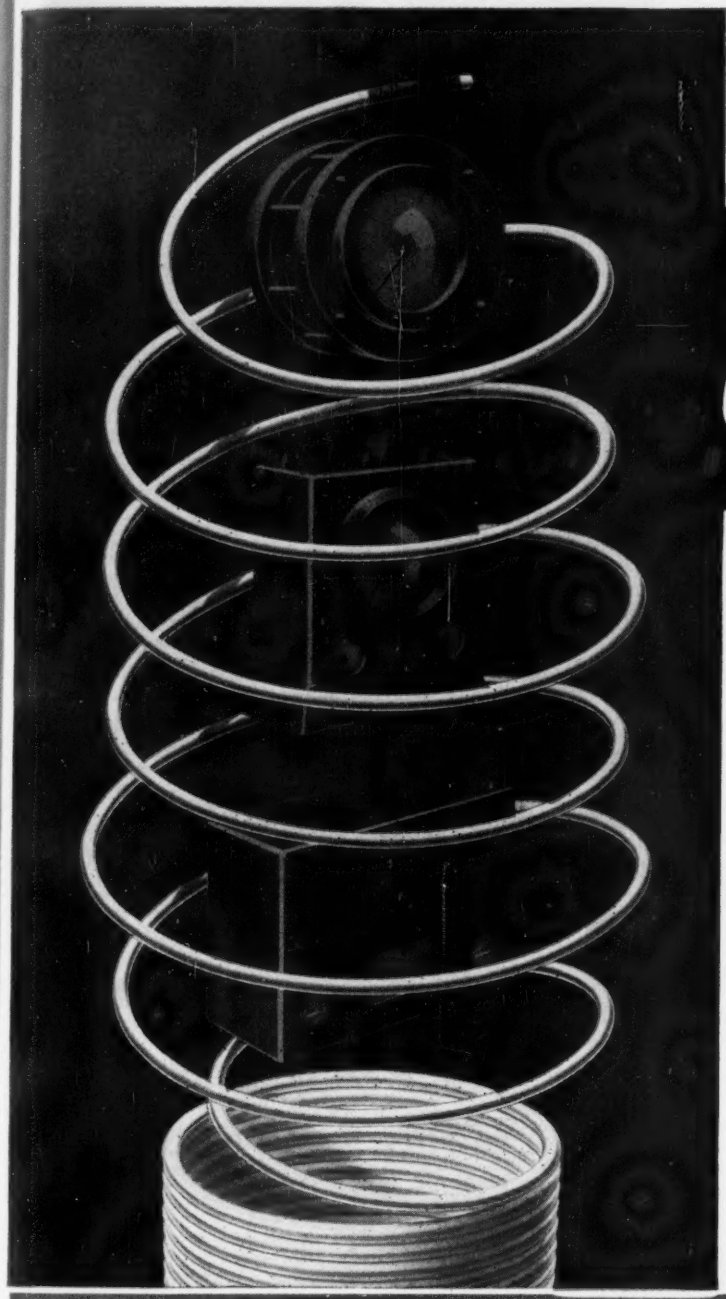

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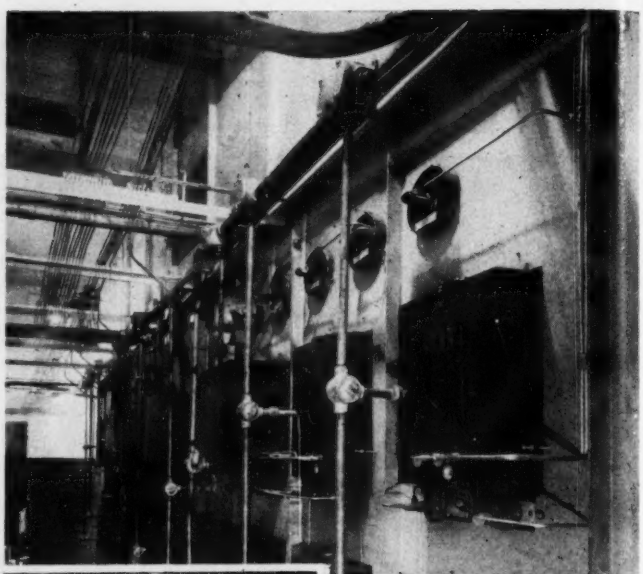
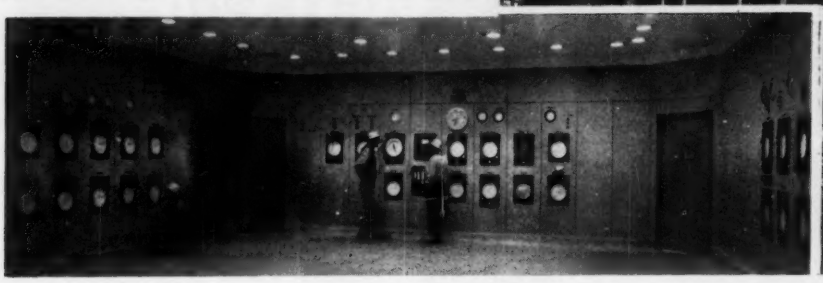
COVER PICTURE STORY

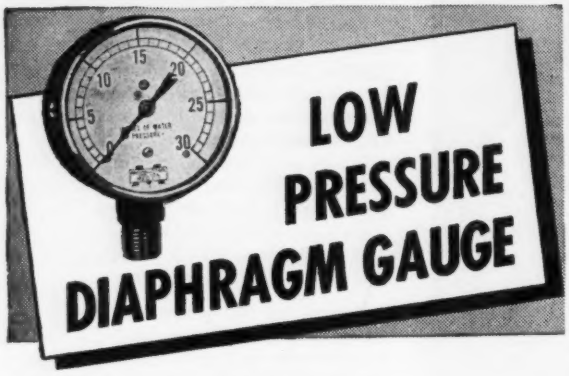
Good Back-of-the-Board Housekeeping

(AN EDITORIAL)

THIS month's "cover hero" is the instrumentation at the Standard Oil of Ohio refinery at Latonia, Kentucky. As usual the oil company's publicity men sent us more than one photograph. Not as usual, the control-room picture was much too wide for using a portion of it to fit our square "cover window." But this turned out to be a good thing because the real hero is not the handsome front-of-the-board but the neat back-of-the-board housekeeping—which must have been a problem on account of the distances involved. Distance is the bugaboo of pneumatics but not for the Sohio instrument men. They did a neat job with 10,000 to 15,000 feet of one-quarter-in. O.D. "3S-O" aluminum tubing, activated-alumina dryers (Pittsburgh Lectro Dryer Co.) and Crawford-type fittings. The job is a year old this summer and we hear that everything works right in spite of "corrosive atmosphere." —M. F. BEHAR







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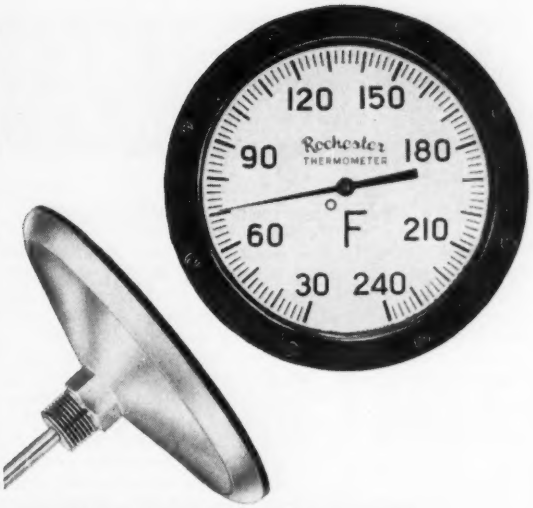

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INSTRUMENTS ON THE MARCH

USAF's New Jet Instrument Trainer

WASHINGTON, D. C.—Realistic ground training for Air Force pilots will soon be provided by the new C-11 Link Jet Instrument Trainer designed to simulate all of the problems and flight conditions encountered by pilots flying high-speed jet aircraft.

Extensive tests of the new equipment have been completed at Air Materiel Command, Headquarters, Dayton, Ohio, and the U. S. Air Force has announced its acceptance for use in the training of jet pilots.

Manufactured by Link Aviation, Inc., Binghamton, N. Y., the trainer includes all of the controls, instruments and indications of a high-speed aircraft with rates of roll, climb and acceleration duplicated. It is essentially a combination of three trainers—flight, engine-operation and radio-navigation—and has a cockpit arrangement conforming closely with the actual cockpit of a jet fighter.

Once the student is under the "hood" of the new device, the check pilot puts him through his problems. The student reacts to flight conditions and emergencies as indicated on the instrument panel as emergencies which might face any pilot in actual high-speed flight.

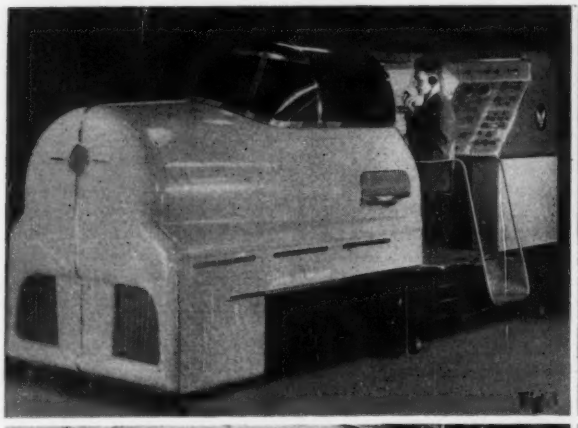
Weather conditions may be varied by the instructor, and light conditions ranging from thin overcast to night instrument conditions may be created through the use of light intensity controls. Icing conditions, rough air and wind can also be introduced by the instructor.

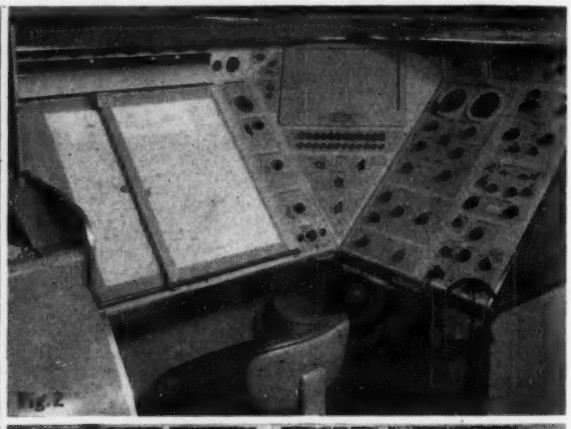
A series of 23 lights, using three colors and located on the control panel, inform the instructor of any errors made by the student in the cockpit. Flight conditions are shown by a duplicate set of instruments on the panel giving the same indications as those instruments in the cockpit.

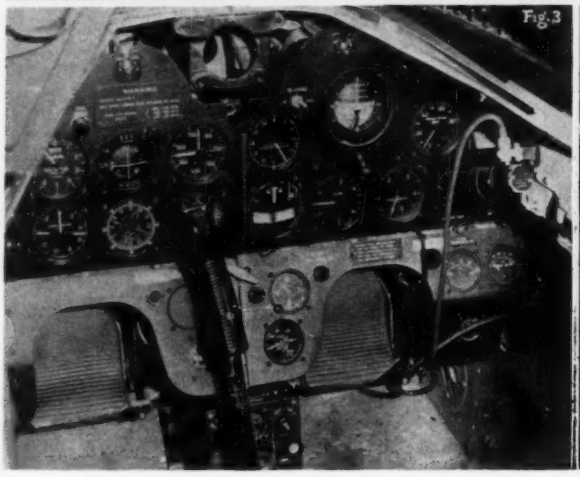
Two of the buttons facing the instructor are labeled "Engine Aircraft Reset" and "Pilot Failure Overide." The first allows the instructor to "give" the student a completely new engine, figuratively, when excessive operating conditions or pilot error threaten engine failure or damage.

The "Pilot Failure Overide" switch has already gained the nickname, "the Angelic Switch." A serious pilot error, or series of errors, can be immediately corrected when the instructor pushes this button. This enables the student to get a fresh start in learning to overcome these errors.

The trainer contains an intricate arrangement of computers which calculate instantly every action on the part







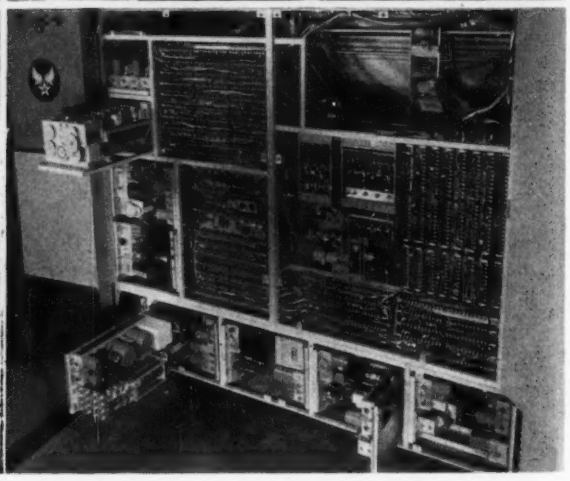


Fig. 1. Over-all view.—The C-11 Link is at once a flight, engine and radio-navigation trainer. It contains all the controls and instruments of a modern jet fighter, which operate as they do in actual flight. Sitting behind the cockpit, the check pilot has an additional set of controls by which he can introduce a wide variety of emergencies into flight problems. Available in a ground trainer for the first time is VHF, Omnirange and offset-course computer equipment.

Fig. 2. The instructor's console, integrally built behind the pilot's cockpit, faces the recorder panel (left) holding duplicate instruments and monitoring lights, and the fuel and radio control panel (right). In the center panel are the twelve emergency control buttons which enable the instructor to introduce fire, engine failure, hot tailpipe, and other emergencies. A reset, or "angelic" switch, forgives all serious disablement and gives the erring student a fresh start. Below the fuel tank filling knobs are complete controls for the radio facilities and voice communication. The Universal Station Locators permit setting in two stations simultaneously at any geographical location on the chart, as either low frequency, VHF, or ILS stations, with adjustment of frequency, approach bearing, maximum reception range, and call-letter identification. Thereafter, fully-automatic response is given to proper manipulation in the pilot's cockpit.

Fig. 3. Pilot's cockpit, Main Panel.

Fig. 4. Easy access is provided to electronic equipment controlling radio and navigational aids. Each chassis unit rolls out for inspection or adjustment, or may be completely removed.

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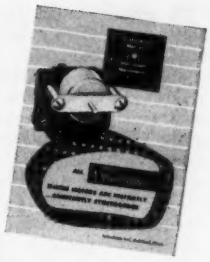

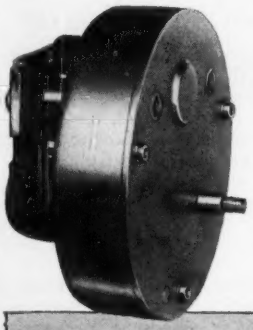

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of the student and translates these indications to the instruments and controls in the cockpit and on the instructor's panel. Operations are based on a series of aerodynamic equations which express all the essentials of jet flight. Electronic computers were designed to solve these equations continuously as their values are changed by such physical inputs as control positions, altitude, throttle setting, etc. There are 24 of these computers. They express the changing solutions in voltages which in turn are fed through amplifiers and servos and finally presented to the pilot as instrument indications, control pressures and radio signals.

The new trainer is 14 feet long and weighs 3750 pounds. Its "fuel consumption" is 6 or 7 kva. of 220-volt a-c. power, costing about six cents per hour.

Complete Mechanization of Plants Far Off

PHILADELPHIA, Penna.—Recent forecasts that the day is rapidly approaching when all kinds of products can be turned out without any manual handling were discounted here by C. E. Kraus, President, Kraus Design, Inc., Rochester, N. Y., speaking before a technical session of the American Society of Tool Engineers at Convention Hall.

"Complete mechanization of plants, where raw material is dumped into an automatic line at one end and the finished product comes out of the other ready to ship to the consumer, is theoretically possible or practical in only occasional instances," Kraus said.

Vast cost reductions in the manufacture of all kinds of products are possible, he stated, but the investment cost in the equipment required may in many cases far more than offset the savings in manual effort. Even in feeding a part into a machine, the sorting mechanism may be extremely complex. Only a ball, he pointed out, can be fed into a machine without its ever being "wrong end to." On the other hand, there are seven wrong ways and only one right way in which some rectangular parts can enter a machine. This means that automatic sorting mechanisms must first arrange the parts according to one "direction," then another, and a third, and so on.

Nevertheless, he urged tool engineers to concentrate on studies of automatic handling mechanisms. "Experience in using and maintaining such equipment must be developed," he pointed out, "just as experience in operating any other kind of high production tools. While some of the simpler hoppers can be applied almost anywhere, experience becomes more and more essential as complications increase."

EDITOR'S NOTE.—At the same ASTE meeting, N. L. Bean of Ford Motor Co. told how 3,000,000 valve guide bushings per month are produced automatically—almost no manual handling from the time the bushings arrive in bins from the foundry to automatic inspection, dipping into various liquids, etc.

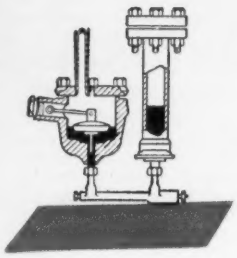
Memory Units for NBS Computer

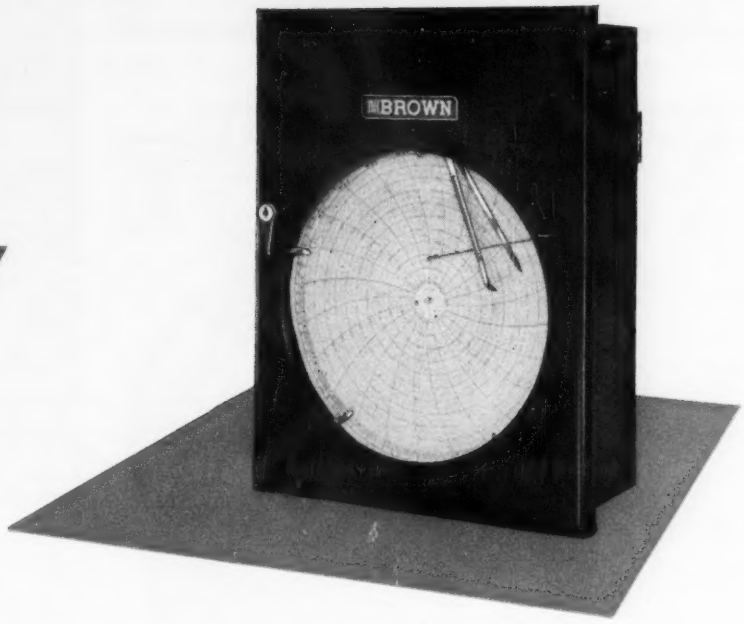
PHILADELPHIA, Penna.—The National Bureau of Standards in Washington has received the first of three memory units to be used in the latest type of large-scale electronic computer developed jointly by funds of the Air Comptroller, Department of the Army and NBS. This automatic brain will remember for later recall any sequence of facts or figures once placed on it.

The memory unit is based on the principle of the mercury delay line originally conceived at the University of Pennsylvania. It has reached its latest development through the joint efforts of the staff of the Electronic Computer Section of NBS under the direction of Dr. S. N. Alexander and the engineers of Technitrol Engineering Co., Philadelphia, under the direction of vice-pres. Gordon Palmer, Jr.

This latest development in computers is known as the NBS Interim Computer. In addition to contemplated work in processing the 1950 census figures, the Interim Computer puters for government and commercial use. It will also be utilized for the solution of many of the scientific problems that arise in the normal work of the Bureau.

THE PRESSURE GAUGE





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FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 731

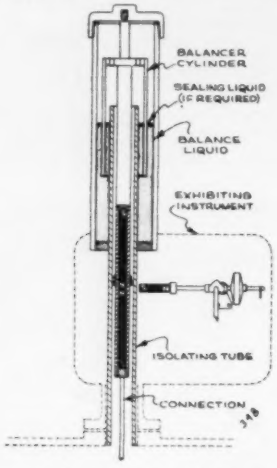
On-off Controller with "Anticipating" Action

New "Model 252P Capacitrol" pyrometer controller achieves straight-line control by using anticipatory voltage without affecting true temperature reading at control point. New circuit compensates for over- and undershooting characteristics of ordinary on-off control.—*Wheelco Instruments Co., Chicago 7, Ill.*

Mention No. 701 when filling out card.

Liquid-level Transmitters

New "Levilimeter" displacer-buoy transmitter permits maker's standard 5-in. travel transmitters to measure any desired change in liquid level.



When operation is to be at atmospheric pressure only, and a direct connection into instrument case from liquid chamber is permissible, a direct mechanical connection can be made from buoy to instrument mechanism.—*Fischer & Porter Co., 751 County Line Rd., Hatboro, Pa.*

Mention No. 702 when filling out card.

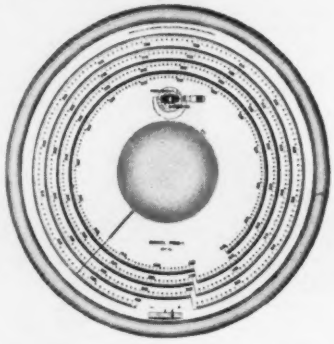
Halogen Analyzer

New "Halide Meter" is a halogen analyzer employing a photoelectric photometer to indicate changes in intensity of blue spectrum of a copper-arc discharge in presence of organic-halide vapors. Readings of instrument are accurate to within 10 percent, and sensitivity for halide derivatives increases approximately as number of halogen atoms per molecule. Dimensions are 15 by 16 by 9.75 in. and weight is 35 lbs.—*The Davis Emergency Equipment Co., Inc., 45 Halleck Street, Newark, New Jersey.*

Mention No. 703 when filling out card.

Microbarometer

New "Precision Microbarometer" model of maker's null-method aneroid barometer is a supersensitive instrument, sensitivity being 0.001 inch of mercury. Range is 24.800 to 31.000 in. Hg (other ranges on request). Etched

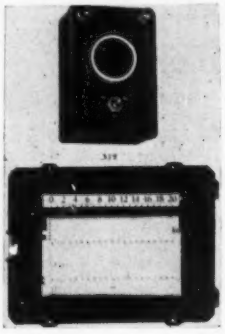


graduations read directly in 0.001 in. Hg. Accuracy guarantee has same value as sensitivity, namely 0.001 in. Hg., which is said to be "the first time in history" for a commercially-available barometer. Instruments are available with wall-mounting flange or russet carrying case.—*American Paulin System, 1847 S. Flower St., Los Angeles 15, Calif.*

Mention No. 704 when filling out card.

Illumination Meter

New photoelectric light recorder employs a photoelectric cell of dry-disk type and a filter to match its color response to that of human eye. Full-scale value of 20, 40 or 80 foot-candles are



selected by a single switch. Recorder can also measure candlepower of any value by proper adjustment of distance from light source.—*Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.*

Mention No. 705 when filling out card.

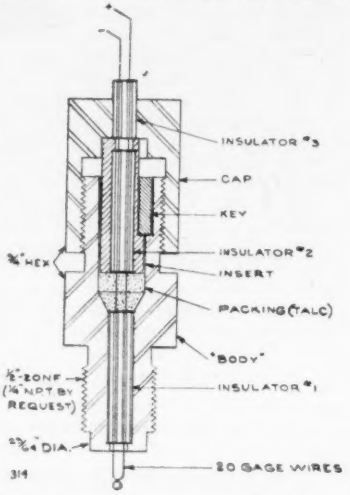
Interchangeable-component Instrument Line

New "Cabinet Series" line of instruments enables user to incorporate auxiliary equipment into the case of a direct-reading electronic controller. Combining equipment to secure a centralized control system protected by lock and key eliminates need for extra instrument panels or housings.—*Wheelco Instruments Co., Chicago 7, Ill.*

Mention No. 706 when filling out card.

Thermocouple Holder

New high-pressure holder for bare thermocouples will seal against pressure to 1000 psi. at 1400 F. or higher pressures when made with 304 stainless



steel. Standard connection for this unit is 0.5 in. National fine thread. In brass construction, useful below 250 F., pressures from vacuum to 4000 psi. may be used. 0.25 in. N.P.T. connection is standard with this unit.—*Conax Sales Co., P. O. Box 72, Kenmore 17, N. Y.*

Mention No. 707 when filling out card.

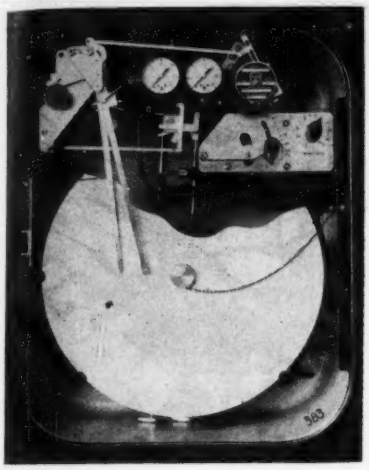
Metering Pump

New "Airoymetric" pump for testing purposes delivers pressures up to 25,000 psi. Capacities up to 405 gph. are secured at lower pressures. Air-cylinder diameters are from 2 to 14 in. with pump-plunger dia. from 0.312 to 3.5 in. Pumps are powered with reciprocating air pistons. Pump is operated at full stroke until predetermined hydraulic pressure is nearly reached and then slows down to speed necessary to maintain required pressure.—*Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia, Pa.*

Mention No. 708 when filling out card.

Air-operated Controllers

New air-operated controllers can be supplied with on-off, proportional, automatic-reset, and derivative control. Nozzle and restriction have sapphire



jewels to prevent wear. Nozzle is fixed with no adjustment possible. Restriction may be cleaned by action of a lever while controller is in service. Channeled passages in relay housing reduce number of tubing connections needed. Relay may be removed separately or with entire control mechanism by breaking one tube connection and removing four screws. Same relay is used for all types of controllers.—*Penn Industrial Instrument Corp.*, 3116 *N. 17th St., Philadelphia* 32, *Pa.*

Mention No. 709 when filling out card.

Moisture Meter

New "Tag Model 8009" moisture meter is direct-reading, calibrated from 7 to 30 percent moisture. To check wood, user inserts needle electrodes in sample, presses button, and reads scale. For

plaster, needles are removed from electrodes. Dimensions are 4.5 by 4.5 by 3.125 in. and weight is less than 4 lbs. Self-contained batteries furnish power. —*Tagliabue Div., Weston Electrical Instrument Corp.*, 614 *Frelinghuysen Ave., Newark* 5, *N. J.*

Mention No. 710 when filling out card.

Program Recorder-Controller

New program recorder-controller eliminates cam cutting by use of a standard set of cams which can be set to conditions required, such as rate of rise, length of hold, and holding pressure or temperature. Holding temperature may be changed with a knob setting. Instrument uses a 9-in. chart;

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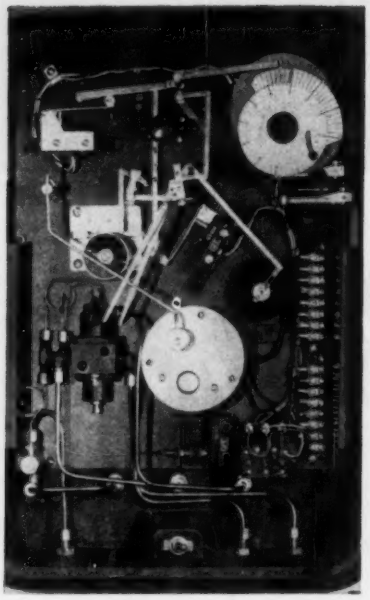
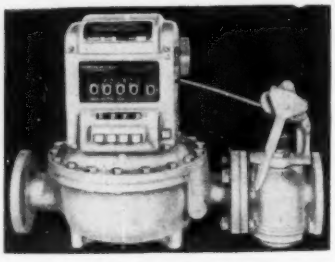


employs maker's standard interchangeable-part assemblies; may be modified to control two variables at one time, to include automatic reset after completion of cycle, to stop cam at any point in cycle, and to provide for relays or signalling devices.—*Gotham Instruments Div., American Machine and Metals Inc.*, 149 *Wooster St., New York* 12, *N. Y.*

Mention No. 711 when filling out card.

Predetermined-quantity Liquid Meter

New meter that automatically controls total quantity of liquids, such as water, liquid sugar, and corn syrup, consists of "Model 432 register" mounted on maker's liquid meter coupled with a quick-closing valve which will automatically shut off flow after a pre-determined quantity has



been delivered. Mechanism is set by pushing buttons on register until number of gallons (or pounds) desired shows up on numeral wheels. After delivery, register is cleared back to zero by turning reset handle at right. Small shuttered totalizer near top of register keeps cumulative totals, from which daily, weekly, or monthly figures can be recorded. Flow can be stopped at any time by pressing emergency-stop button on face of register.—*Neptune Meter Co.*, 49 *W. 49th St., New York* 20, *N. Y.*

Mention No. 712 when filling out card.

Double-acting Pneumatic Power Unit

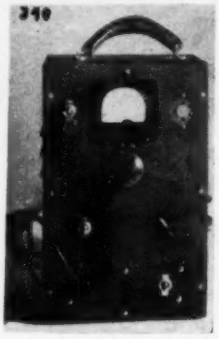
New double-acting pneumatic cylinder may be operated by use of a three-way valve and still allow throttling to provide for control of work and of return stroke. After initial charge of air, cylinder operates on same number

of cubic feet of air as a spring-return cylinder. In effect, it is a double-acting cylinder—requiring only half the volume of air needed to operate a double-acting cylinder. Available in 1.125, 1.75 and 2.5 in. dia., there is no metal-to-metal contact, no moving parts to wear, except "O" rings, replacement of which renews cylinder.—*Modernair Corp.*, 4222 *Hollis St., Oakland* 8, *Calif.*

Mention No. 713 when filling out card.

Portable Bridge for Thermometry

New "Speed Bridge" thermometer is available in any range from temperature of liquid gases to 1400 C. Dial has 1000 divisions, readable to 0.1 de-



gree with sensitivities of 0.01 degree. Bulb may be up to several hundred feet away from bridge. Operation is from 115-v. 60-cps. line. Case is 7.75 by 12 by 7 in.—*Paul G. Weiller*, 95 *Broad St., New York* 4, *N. Y.*

Mention No. 714 when filling out card.

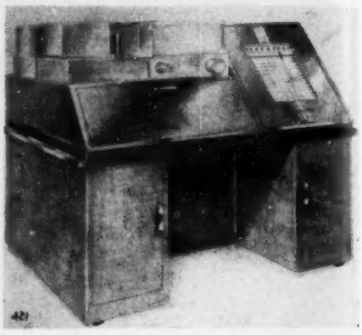
Platinum Thermometer

New precision platinum thermometer has sensitive tip 5 mm. O.D. and 1.5 in. long for a resistance of 25.5 ohms. Stem is 7 mm. dia. and can be several feet long if required. Wire is of platinum 0.050 in. dia. onto which a glass coating is fused. A resistance winding is placed on this coating, one end being connected to center wire. An outside coating of Pyrex glass is fused on winding. Four leads of fine gold wire are provided. Unit is monofilar. Characteristics of unit are identical with those of maker's precision platinum thermometer.—*Paul G. Weiller*, 95 *Broad St., New York* 4, *N.Y.*

Mention No. 715 when filling out card.

Infrared Spectrometer

New "Model 12-C" infrared spectrometer operates wherever water and electricity are available. Controls and recorder of new cabinet are accessible to operator in either a sitting or standing position. Over-all dimensions of caster-

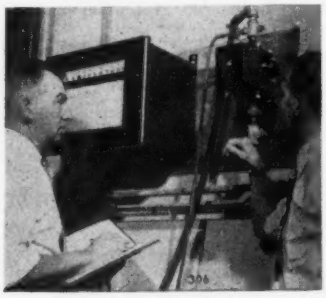


mounted cabinet are 54 by 46 by 30 in. "Speedomax G" recorder will be included as standard equipment to accompany increased chopper speed of new "Model 81" amplifier. "Electronik" recorders will be available if desired. Wavelength drive has simplified, reversible speed-change controls.—*Perkin-Elmer Corp., Glenbrook, Conn.*

Mention No. 716 when filling out card.

Recording Turbidimeter

New photoelectric recording turbidimeter can be set to read any desired range such as 0 to 10 parts per million,



100 to 1000 ppm., 90 to 100 ppm., etc. Range is from turbidity of tap water to that of Mississippi River water.—*General Electric Co., Schenectady* 5, *N. Y.*

Mention No. 717 when filling out card.

Resistance Thermometers

New "Type 1000" extends useful range of resistance thermometers to 1000 C. in measurement and control. Its element, sealed in a quartz chamber, is tungsten; and chamber is evacuated prior to sealing. Three-lead method is

used to compensate for temperature change in leads. Unit is available either with or without protective jacket. Resistance is 25 ohms at 25 C, and sensitivity is 0.1 ohm per degree C. Sensing length is 2 inches; over-all length 18 inches. Diameter of sealed quartz chamber is 0.25 in. and of jacketed assembly is 0.34 in. Upper temperature limit is 1000 C.—*W. S. MacDonald Co., 33 University Rd., Cambridge 38, Mass.*

Mention No. 718 when filling out card.

Micromanometer

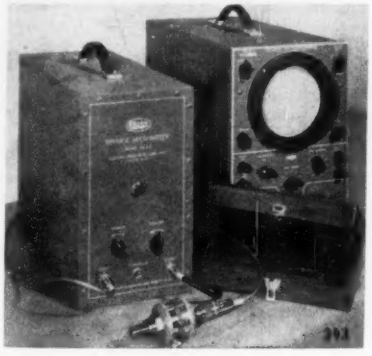
New "Model 179" micromanometer consists of sensing unit and a separate electronic indicator which can be mounted at some distance from sensing unit. Indication of pressure is independent of condensable vapor in sys-

tem and is read directly from scale of a 4-in. instrument calibrated in 1-micron steps and having a full-scale value of 50 microns. Interconnection of two units is by means of concentric cables.—*Clarke Instrument Corp., 910 King St., Silver Spring, Md.*

Mention No. 719 when filling out card.

Vibration Micrometer

New vibration micrometer utilizes change in reactance of a sensing coil developing a high-frequency field when an external metal body enters field. All measurements are made without con-



tacting metal body; displacements are shown on oscilloscope screen. Movements as small as 0.0001 in. are measured with a sensitivity equal to 1 percent of total displacement. Measurements are independent of acceleration or frequency.—*Electro Products Labs., Inc., 4501 N. Ravenswood Ave., Chicago 40, Ill.*

Mention No. 720 when filling out card.

Metal Sorter

New "Cyclograph" sorts metal parts of any size of their metallurgical characteristics. Operating on magnetic principles, it can sort by mixed analysis of part: structure, hardness, case depth,

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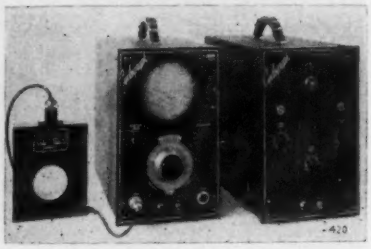


brittleness, or almost any metallurgical difference. Testing speeds of 1 to 5 parts per sec. can be attained when parts are sent through test coil on a belt conveyor. Instrument can be used to reject only parts giving a low reading or to reject both above and below an established acceptable range.—*J. W. Dice Co., 1 Engle St., Englewood, N. J.*

Mention No. 721 when filling out card.

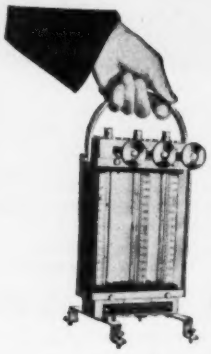
CRO-type Analyzer

New "Analascope" cathode-ray type analyzer uses a 5-in. tube for continuous observation of non-recurrent sweeps of from 0.01 to 5 sec. A two-decade potentiometer calibrated with a self-contained standard cell provides direct measurements from 0.001 to 15 pH and 0.1 mv. to 1.5 v. An input attenuator of 1,000 megohms provides overlapping ranges of 1 uuamp. to 10 ma. and 1 mv. to 100 v. per cm. deflection. Other phenomena which may be measured are: pressure, strain, electrocardiograph impulses, etc., which may be converted to electrical impulses.—*Analytical Measurements, Inc., 585 Main St., Chatham, N. J.*

Mention No. 722 when filling out card.

Triple-meter Kit for Flow-rate Studies

New flowmeter kit has three metering tubes with two special floats for each tube made of Pyrex and tantalum. Flow range is 0.1 cc. per min. to 0.5 gpm. liquid, and 5 cc. per min. to 2 cfm. air. Unit can be equipped with brass or Type 316 stainless-steel needle valves. End fittings are available in steel, brass, aluminum, 303 and 316 stainless, hard rubber, nickel, Monel, Durimet, and Hastelloy C. Total weight is 15 lb.—*Brooks Rotameter Co., Box B-5550, Lansdale, Pa.*

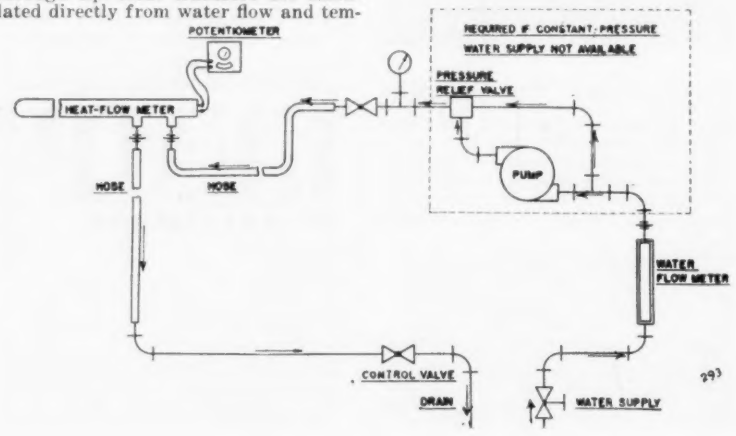


Mention No. 723 when filling out card.

Heat-flow Meter

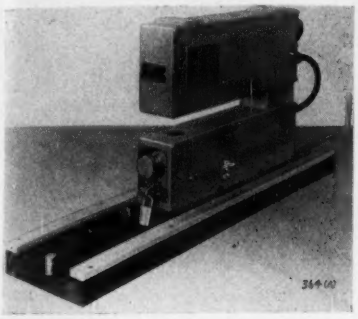
New heat-flow meter works on principle of continuous calorimetery. It consists of two concentric stainless-steel tubes, furnished in various lengths, through which a known flow of water is passed. Thermocouples measure rise in temperature of water passing through tip. Heat transfers are calculated directly from water flow and temperature difference. Instrument serves as a probe for making traverses in heat-transfer zones.—*Thermal Research and Engineering Corp., 73 Pond St., Waltham 54, Mass.*

Mention No. 724 when filling out card.



Continuous Thickness Gage

New continuous thickness gage uses radioactive source to provide beta rays, absorption of which in a continuously-moving strip gives an indication of strip or sheet thickness. Range is 5



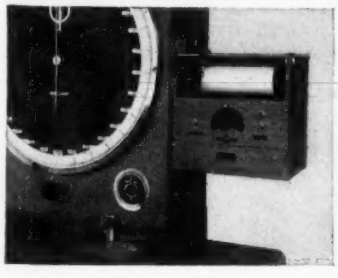
to 150 oz. per sq. yd. with strontium-90 as source, or 50 to 300 oz. per sq. yd. with ruthenium-106 as source. Readings are accurate to 1 percent. Normal throat depth of gaging head is 12 inches

from center line of radioactive beam, but a two-piece gaging head with traverse mounting can be supplied when it is desired to scan entire width of sheet. *—Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford, Conn.*

Mention No. 725 when filling out card.

Strain Recorder

New strain recorder features a multi-position switch which selects magnification of strain from 1000:1, 500:1, 250:1, 100:1, 50:1, 20:1, and 10:1 without gear changes. Operator changes from one magnification to another during test without affecting values of test data. Unit may be used with either an extensometer or compressometer for



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STRESS — STRAIN ANALYSIS

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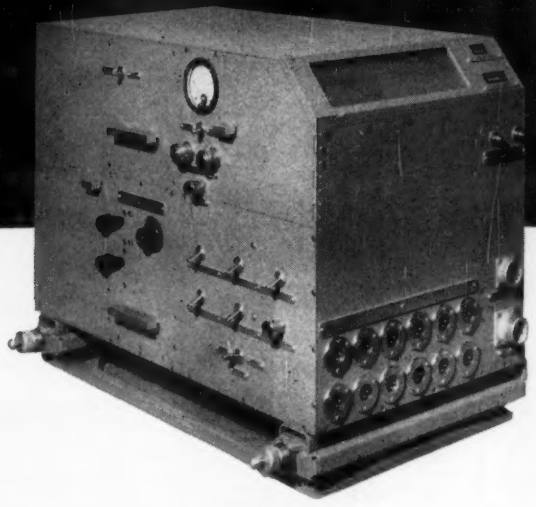

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3. Instantaneous changes of recording speeds up to 50" per second with automatic adjustment of lamp intensity.
4. Timing System — Discharge lamp controlled by temperature compensated tuning fork providing sharp .01 second with heavier .1 second timing lines. Conversion to .1 second lines only, by switching.
5. Independent optical system provides constant view of traces with optimum light intensity at all times.
6. Recording lamp under constant surveillance of external condition indicator lamps.
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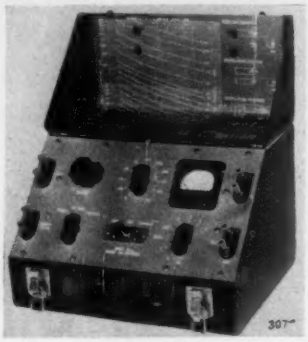
recording tension, compression, and tranverse-test data. Load scale is spread over 182 in. for each range.—*Tinius Olsen Testing Machine Co.*, 1116 *Easton Rd., Willow Grove, Pa.*

Mention No. 726 when filling out card.

Dynamic Strain Amplifier

New "Model BA-1" portable strain amplifier reproduces all frequencies between 5 and 20,000 cps. Ample gain is provided to operate any standard

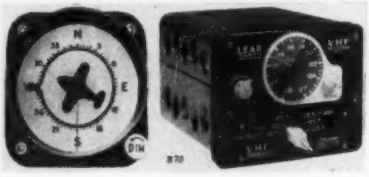


cathode-ray oscilloscope. Microinches in strain can be determined by using graphed curves in cover of instrument. Instrument weighs 22 lbs. with batteries; is designed for use with SR-4 bonded resistance-wire strain gages.—*The Baldwin Locomotive Works, Philadelphia* 42, *Pa.*

Mention No. 727 when filling out card.

Automatic Aircraft Navigating System

New "Omnimatic" system for the VHF Omnirange navigating system gives continuous instantaneous magnetic bearing from aircraft to selected



VOR range station plus reception facilities of all VHF towers and radio ranges and 3-frequency VHF transmission. Equipment is also available without transmitter.—*Lear Inc.*, 110 *Ionia Ave., N. W., Grand Rapids* 2, *Mich.*

Mention No. 728 when filling out card.

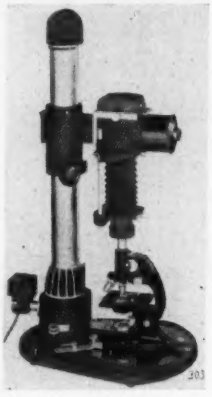
Metering Pump

New "No. 6100" metering pump for hot waxes and cements has a tank capacity of 1.5 gallons. Discharge can be changed within 2 sec. from one-sixty-fourth to five-sixteenths oz. per ejection in 20 equal increments, with an accuracy of 3 percent. Power required is 1880 watts.—*Edward E. Robinson, Inc.*, 95 *Park Ave., Nutley* 10, *N. J.*

Mention No. 729 when filling out card.

Photomicrographic Apparatus

New "Orthophot" photomicrographic apparatus is used with any standard microscope and comprises: a base with built-in light source balanced at 3200 K



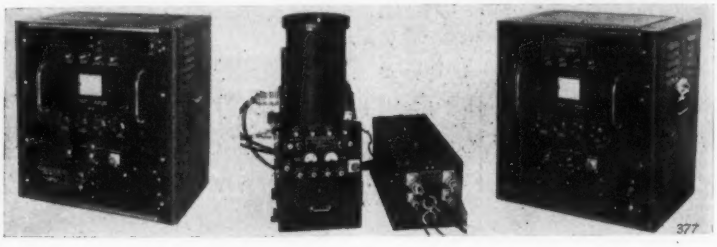
with intensity control and color filters; a reflex camera for use with 120 roll-film, 2.25 by 3.25 in. cut or pack film, or 35-mm. film; and a vertical column with counterbalanced elevating device.—*Silge & Kuhne, Box I*, 153 *Kearny St., San Francisco* 8, *Calif.*

Mention No. 730 when filling out card.

Dew-point Indicators

New "Types D- 1, 2, and 3" dew-point indicators have ranges from –80 to 40 C. with a response of 5 C. per second. Instruments measure temperature of a small mirror surface which is automatically controlled to maintain a thin film of dew or frost of constant thickness at all times. First type, for remote locations, will operate unattended for an indefinite time; second operates for eight hours on one filling in aircraft; third is designed for laboratory cold-chamber use and operates for 8 hours per filling.—*Cook Electric Co.*, 1457 *Diversey Pkwy, Chicago, Ill.*

Mention No. 731 when filling out card.



MODERN ELECTRONIC ENGINEERING GIVES PRECISE

FINGERTIP SPEED CONTROL

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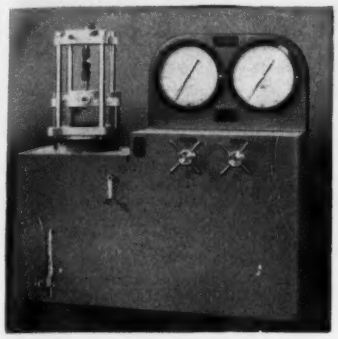
- TENSION OR POSITION CONTROL
- MOTOR INTEGRATORS
- BI-DIRECTIONAL
- DYNAMIC BRAKING
- SERVO CONTROL

Servo-Tek products co
4 Godwin Ave. Paterson, N. J

Universal Testing Machines

New low test ranges can be added to any maker's "L" machine in standard capacity up to 600,000 psi. Unit operates without necessity of stopping test while load change is being made.

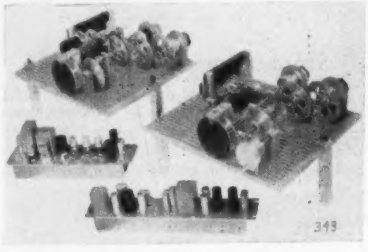


New range is 1,000 lbs. in 2-lb. increments. The Electronic null system receives signals from hydraulic pressure in cylinder of machine, and translates them into rotary motion of pointer. Accuracy is guaranteed within ASTM requirements.—*Tinius Olsen Testing Machine Co.*, 1116 *Easton Rd., Willow Grove, Pa.*

Mention No. 732 when filling out card.

Educational Servomechanism Kit

New servomechanism kit can be assembled as easily as a toy erector set; can be used in working out control problems on continuous processes, such as chemicals, glass and steel, as well as

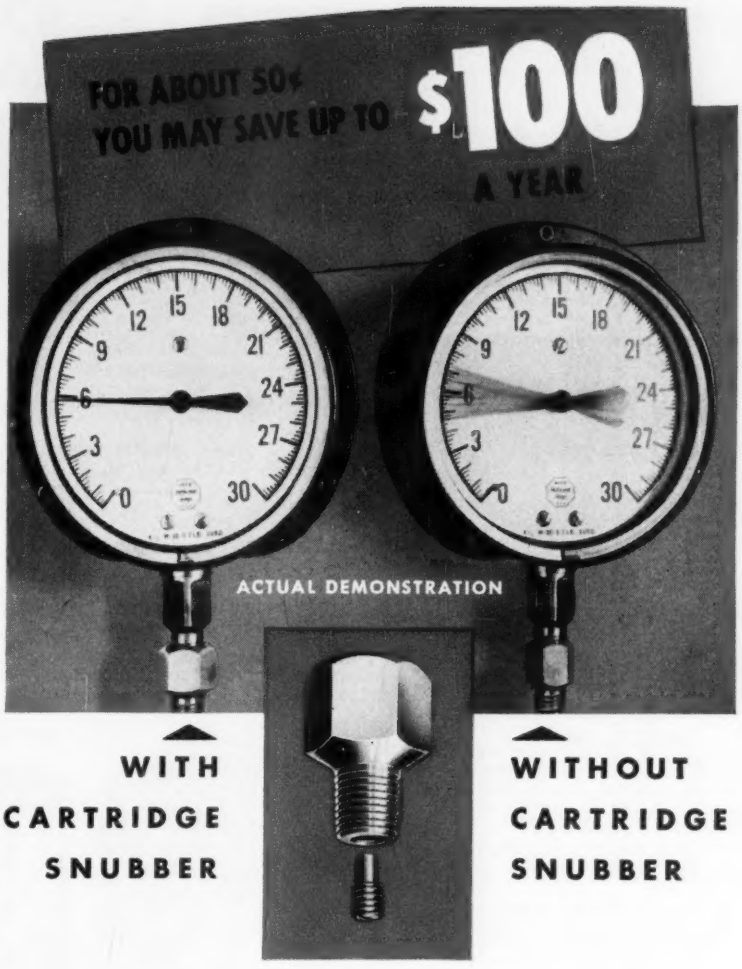


in aeronautical and automotive experimentation. Shown are two completely-assembled servo breadboards (receiver and transmitter) and two servo amplifiers.—*Claude Neon, Inc., Reeves Instrument Div.*, 215 *E. 91st St., New York, N.Y.*

Mention No. 733 when filling out card.

Combination Prime Relay and Power Relay

New "Aminco Electronic Relay" operates from a range of control currents of 3 uamp. to 1 ma. and resistances of 1,700 ohms to 1.5 megohms to control loads up to 20 amp. at 250 v. Switch converts from n-o. to n-c. operation. Control circuit operates with 6-v. a.c. potential. Plus or minus 10-percent line-voltage fluctuation does not affect operation. Control leads up to 2,000 ft. may be used. 502-A thyratron tube operates at half rating and at re-



● Why wreck gages needlessly? When pressure pulsations are so rapid that the gage pointer vibrates excessively, a HELICOID Cartridge Snubber is needed. This is the most simple and effective of all pressure pulsation dampeners. It is threaded into the gage socket for only 54¢. It may save you up to $100.00 a year in gage replacement expense!

For severe pulsation services, order your Helicoid gages with snubber cartridges in the socket. Or, order complete snubbers separately. Specify for water, air or oil; ¼" or ½"; bronze or stainless steel.

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Bridgeport 2, Connecticut

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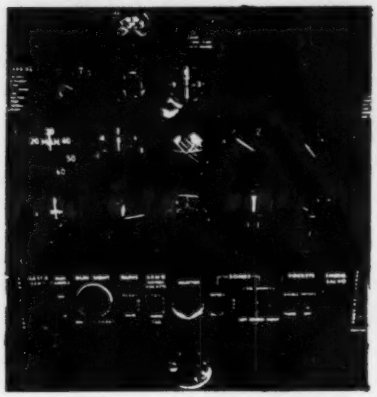
duced filament voltage. Instrument is designed for use with thermoregulators, floatless liquid level control, and similar applications.—*American Instrument Co., Inc., Silver Spring, Md.*

Mention No. 734 when filling out card.

Illuminated Panels

New type of illuminated panel made of clear plastic with white and black bondings permits figures to be processed into black surface so that white appears against the black background.

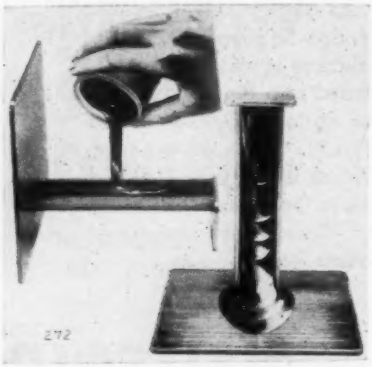


Red lights, illuminating white figures, result in a soft-red illuminated figure which does not disturb eyes in dark.—*Universal Aviation Corp., 230 Park Ave., New York, N. Y.*

Mention No. 735 when filling out card.

Flow Gage

New "Daniel" flow gage for silk-screen paints and roller-mill pastes consists of a semi-circular trough which is filled in horizontal position and then

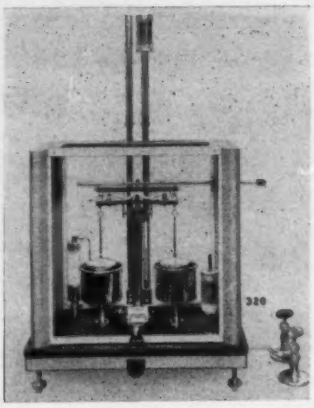


up-ended quickly so that fluid flows down and over calibrated scale. Scale readings are taken over a period up to about 1 minute.—*Henry A. Gardner Lab. Inc., 4723 Elm St., Bethesda, Md.*

Mention No. 736 when filling out card.

Laboratory Gas Balance

New "Anubis" laboratory gas balance employs dryer to remove gas moisture, and also corrects for temperature and barometric pressure. Instrument



handles a specific-gravity range from 0.5 to 1.5 and, by use of weights, a total range of 0 to 2.5.—*American Recording Chart Co., 3115 E. 11th St., Los Angeles 23, Calif.*

Mention No. 737 when filling out card.

Stereoscopic-effect Projector

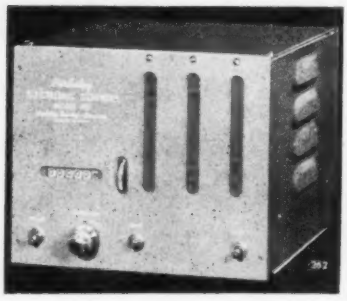
New stereoscopic-effect projector, using Polaroid filters and viewing glasses, employs special metallic screen to attain proper reflection. Lenses are

3.5-in. coated, F-2.8 with two 500-watt lamps for home projection or 750 or 1000-watt lamps for large audiences. Projector is readily converted to conventional color-slide projection. A jig will be available for mounting stereo slides.—*David White Co. Inc., 315 W. Court St., Milwaukee, Wis.*

Mention No. 738 when filling out card.

High-speed Industrial Counter

New "Model 410" industrial counter will register each pulse regardless of fluctuations in occurrence rate, provided that minimum time between any two counts is 0.00002 sec. Count in



digits, tens and hundreds is registered on illuminated panels of three electronic decimal-counting units; output from last unit is registered on a 6-place mechanical counter. Unit can be set to produce an electrical output after every 10, 100, or 1,000 counts. It can be used to determine frequencies up to 10,000 cps.—*Berkeley Scientific Co., 6th and Nevin Ave., Richmond, Calif.*

Mention No. 739 when filling out card.

Automatic Process Timer

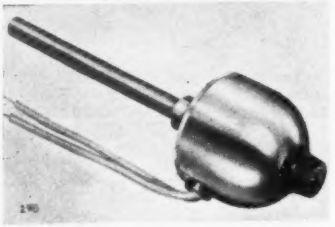
New "Cycl-Flex" timer is designed with auxiliary contacts operated by clutch solenoid which provide four different load-circuit combinations. Either

a momentary or maintained-contact pilot switch can be used to start timer. Timer is rated at 10 amp., 110 v. and is available for 60, 50 and 25 cps. current. Time scales are available from 0-30 seconds to 0-10 hours.—*Eagle Signal Corp., Moline, Ill.*

Mention No. 740 when filling out card.

Immersion Thermostat

New immersion thermostat comprises a metal tube and rod of different coefficient of expansion, bonded to each other at one end. Opposite end of rod operates a switch mounted on a casting.



Rating is 1500 watts at 115-230 v. a.c. non-inductive load. It can be supplied in various adjustment ranges to operate at temperatures from –100 F to 700 F.—*George Ulanet Co., 417 Market St., Newark, N. J.*

Mention No. 741 when filling out card.

Moisture-content Indicator

New "Model RF4" moisture-content indicator is usually provided in range of 0 to 25 percent. Spring-loaded electrodes use no needles; give penetration up to 2 in. for lumber. Shockproof tube

CHACE BIMETAL . .

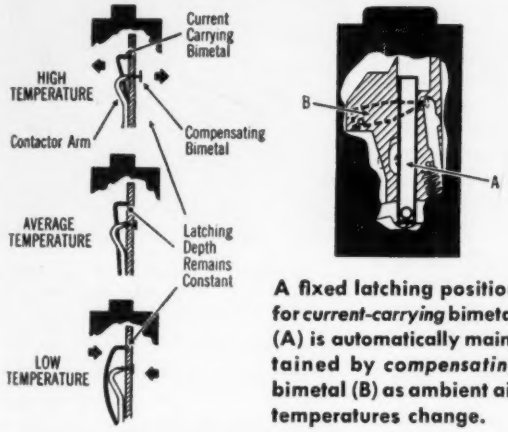
Workhorse . . . Watchdog

IN BULLDOG'S *Pushmatic*® BREAKER

No. 41—Product of BullDog Electric Products Co. Detroit 32, Michigan

Chace Thermostatic Bimetal performs two essential functions in the new BullDog "Pushmatic" circuit breaker. The first is its normal "workhorse" role as actuating element for automatically tripping the breaker on overload or short circuit currents. A second, more unusual job is that of a "Watchdog", noting and compensating for changes in ambient air temperature; this allows the breaker to carry full rated load through a wide range of temperature variations.

HOW CHACE BIMETAL MAINTAINS CONSTANT LATCHING DEPTH



A fixed latching position for *current-carrying* bimetal (A) is automatically maintained by *compensating* bimetal (B) as ambient air temperatures change.

This double-duty performance is typical of the versatility that product designers expect . . . and obtain . . . when they take advantage of the wide range of properties available in our complete line of thirty bimetals. Chace Thermostatic Bimetal can be furnished in strips, coils, special long lengths . . . or in completely-fabricated elements and sub-assemblies, ready for installation in your product.

If operation of your product requires control by thermally-actuated devices, take advantage of our long experience in the manufacture and application of thermostatic bimetal. Consult a recognized authority . . . the Chace Application Engineer.

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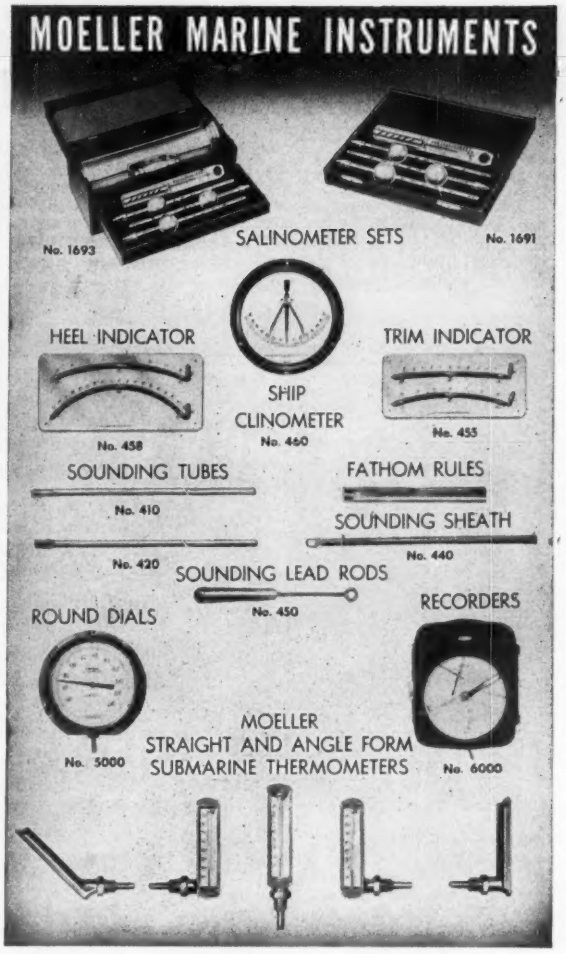

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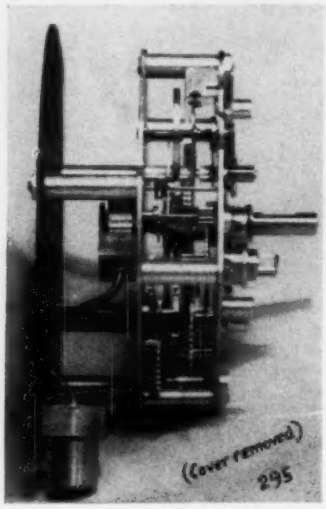
unit and automatic battery-voltage control gives stable circuit. Calibrations are given for 80 wood varieties. Total weight is 7 lb.—*Moisture Register Co., 133 N. Garfield Ave., Alhambra, Calif.*

Mention No. 742 when filling out card.

Pneumatic Chart Drive

New pneumatic chart drive will operate directly on 15 to 30 psi. It can be used on higher pressure through commercially-available pressure reducers. It was designed for use with re-



corders and controllers in explosion-hazardous conditions or as replacement units for d-c. or key-wound clocks where air is available.—*Danco Instruments, Inc., 1835 New York Ave., Huntington Station, N. Y.*

Mention No. 743 when filling out card.

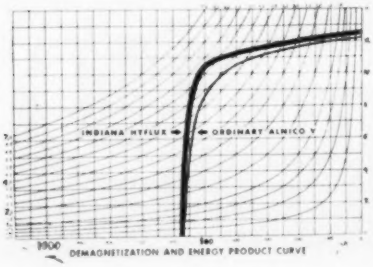
Thermocouple Wells

New line of drilled-type metal protecting wells for thermocouples, comprising nine basic types in 24 different metals and special alloys, is available (as of May 1950). All wells are tested to internal pressures of 75 psi.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne and Roberts Avenues, Philadelphia 44, Pa.*

Mention No. 744 when filling out card.

Permanent Magnets

New "Hyflux Alnico V" permanent magnets with an energy product of at least 5.25 million BHmax. are result of



a new production technique applied to Alnico V.—*The Indiana Steel Products Co., Valparaiso, Ind.*

Mention No. 745 when filling out card.

Standardized A-c. Timing Motors

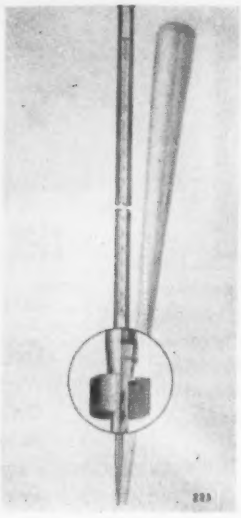
New standardized a-c. timing motors are of synchronous hysteresis type which run at full synchronous speed over a wide range despite variations as

great as 25 percent in line voltage. Features include shaded-pole starting, capilliary lubrication and welded construction.—*A W. Haydon Co., Waterbury, Conn.*

Mention No. 746 when filling out card.

Burette-and-valve Assembly

New "Ultramax" burette employes a throttling valve using a Teflon plug

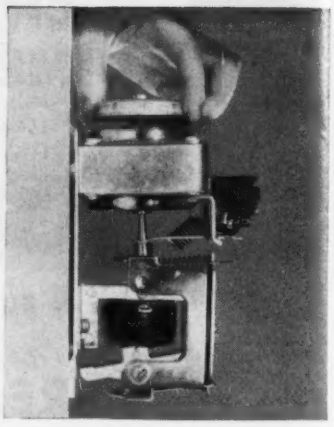


with an assembly which creates a positive-pressure seal without requiring lubrication.—*Emil Greiner Co., 20-26 N. Moore St., New York 16, N. Y.*

Mention No. 747 when filling out card.

Pneumatic Time-delay Relays

New "Type AM" pneumatic time-delay relays, adjustable from 0.2 to 200 seconds have micro-movement-type precision snap switches with double contacts rated at 15 amp., 115 v. continuous duty. Relays are available as open or enclosed units in NEMA type-I enclosures with conduit knockouts at

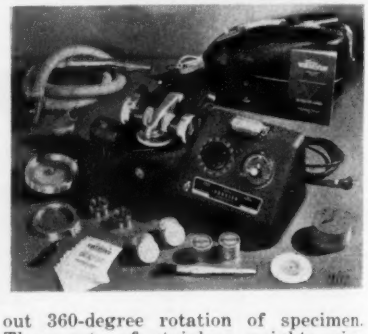


top and bottom. Coils are available in ratings up to 600 v. a.c., 25 to 60 cps.—*Westinghouse Electric Corp. P. O. Box 2099, Pittsburgh 30, Pa.*

Mention No. 748 when filling out card.

Abrasion Wear Tester

New "Model 140" abrasion wear tester abrades specimen with dual wheels which give crossing-wear paths through-

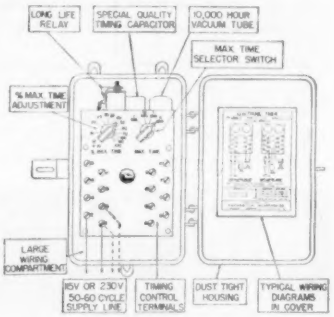


out 360-degree rotation of specimen. Three sets of stainless weights give ranges of 250, 500, and 1000 grams.—*Taber Instrument Corp., 111-I Goundry St., N. Tonowanda, N. Y.*

Mention No. 749 when filling out card.

Automatic Timer

New "Series 30" automatic timer provides for interval, delayed action, automatic repeat, and programming timing. Contact ratings are 10-amp. 115-v.a.c. non-inductive or 5-amp. 230 v., with auxiliary contacts rated at 1

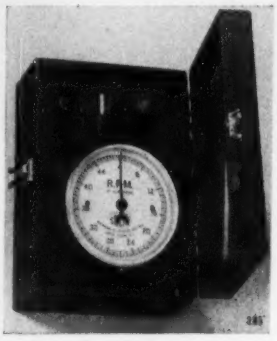

LONG LIFE RELAY
SPECIAL QUALITY TIMING CAPACITOR
10,000 HOUR VACUUM TUBE
MAX TIME SELECTOR SWITCH
% MAX TIME ADJUSTMENT
LARGE WIRING COMPARTMENT
115V OR 230V 50-60 CYCLE SUPPLY LINE
TIMING CONTROL TERMINALS
DUST TIGHT HOUSING
TYPICAL WIRING DIAGRAMS IN COVER

and 0.5-amp. 115-v., non-inductive. Intervals repeat to within 2 percent. Ambient temperature is 32-150 F., and ambient relative humidity is 20-95 percent.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Mention No. 750 when filling out card.

Hand Tachometer

New "Model JP" hand tachometer has a 3-in. dial and a range of 400-4800 rpm. Lens is plastic and carrying case



is velvet-lined with two contact tips. Instrument is unaffected by temperature or magnetic conditions.—*Herman H. Sticht Co., Inc., 27 Park Place, New York, N. Y.*

Mention No. 751 when filling out card.

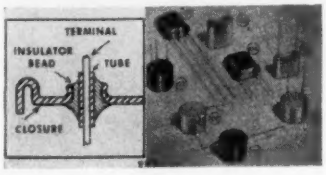
Photocell for Color Film

New photocell for use with color film is said to be for replacing present photocells "in all existing exposure meters" so that they will be corrected to have "the same spectral sensitivity range as the color film."—*Photo Research Corp., 127 West Alameda Avenue, Burbank, Calif.*

Mention No. 752 when filling out card.

Bimetal Thermostats

New line of bimetal disc and bimetal strip thermostats hermetically sealed in a corrosion-resistant metal enclosure have operation from —60 to 600 F.



Terminals are sweat-soldered into inert-metal tubes interfused with inorganic-glass insulator bead in closure.—*Stevens Mfg. Co., Inc., 69 S. Walnut St., Mansfield, O.*

Mention No. 753 when filling out card.

Cement Flow Tester

New 10-in. dia. motor-driven flow table for testing flow consistency of portland cement, meets latest (June, 1949) specifications of A.S.T.M. Apparatus consists essentially of 10-in. dia. flow table, motor drive, and bracket

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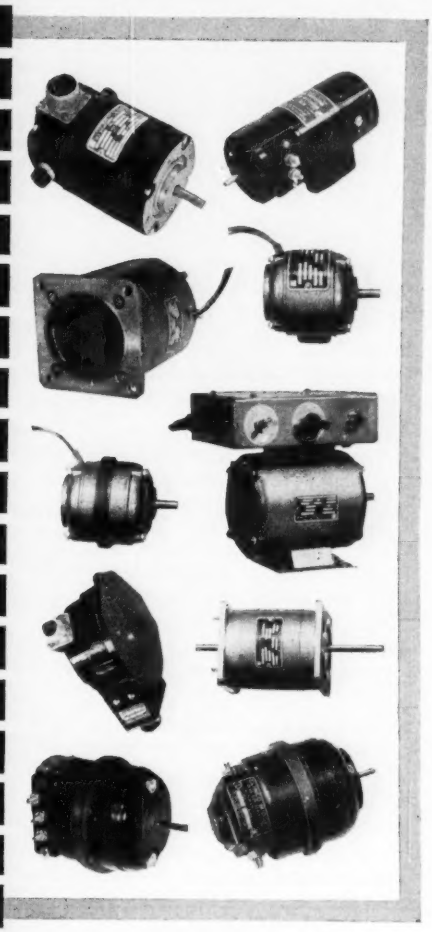

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- ★ Application engineering to adapt the Bendix-Pacific System to each specific problem.
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- ★ Aircraft and missile antenna design and radiation analysis.
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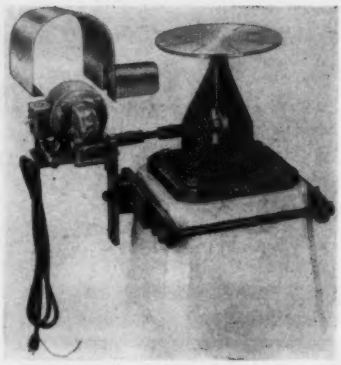
TO MEASURE—TO INDICATE—TO WARN AT A DISTANCE

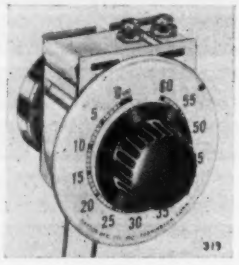


for mounting on a concrete pedestal. Table shaft and cam revolve at 108 rpm., which results in 25 drops of table in about 14 seconds.—*American Instrument Co., Inc., Silver Spring, Md.*

Mention No. 754 when filling out card.

Interval Timer

New "8006 series" interval timer is for intervals of 1, 15, 60 and 180 min. or 5 min. to 60 days on special order. Series is U. L. approved for 28 amp., 1 hp., 250 v. a.c. Unit has a snap-action



device for positive break. Motor is totally enclosed. Knob can be set in either direction, to start or when operating. 450 rpm. rotor is said to provide unusually long life and quiet operation.—*Haydon Mfg. Co., Inc., Torrington, Conn.*

Mention No. 755 when filling out card.

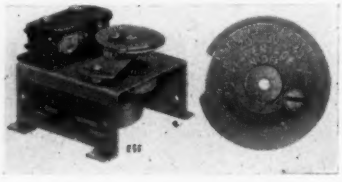
Micro-particle Size Classifier

New "No. 6000" micro-particle classifier centrifugally divides dusts into grain-size fractions with a range of 4 to 60 microns. Separation into eight sizes of a sample requires not over two hours.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.*

Mention No. 756 when filling out card.

Automatic Timers

New "Series CM" cam recycling timers provide over 650 different time cycles from 2 to 98 percent of cycle

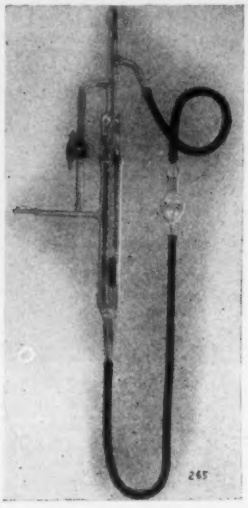


time which can be obtained in a range from 15 sec. to 72 hours. A s-p. c-t. snap-action switch controls load.—*Industrial Timer Corp., Newark, N. J.*

Mention No. 757 when filling out card.

Gas-flow Control Apparatus

New "No. 1611" gas-flow controller utilizes a tapered porous ceramic tube for fine control of gas flow through a system. By use of a large-capacity



reservoir, apparatus may be used as a thermoregulator.—*Kahl Scientific Instrument Corp., P. O. Box 1166, El Cajon, Calif.*

Mention No. 758 when filling out card.

Voltage Reference Standards

New line of voltage standards usable as laboratory standards or as components are sealed and guaranteed to maintain rated output for a period of six months. Illustrated is "Model VS50-50"; output is 50 v.d.c. Dual output terminals are provided, either

of which has a capacity of 50 ma. Internal impedances of output are 8.5 and 700 ohms. After a thirty-minute stabilization period, all standards have following specifications in common: Input voltage range, 100 - 130 v.a.c., 45 to 800 cps.; regulation accuracy, 0.5 percent; ripple, less than 0.5 percent; temperature range, 60 - 100 F. Unit measures 5 by 6 by 8 in. Ratings range from 2 to 300 v.d.c.; from 15 to 50 ma. —*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Mention No. 759 when filling out card.

Stabilized D-c. Indicating Amplifiers

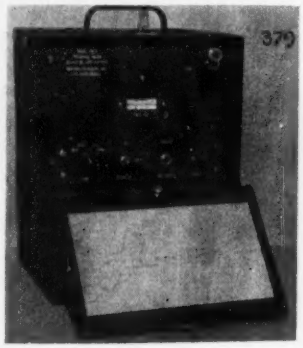
New stabilized d-c. indicating amplifiers are supplied either as voltage or current type, with choice of zero-left or zero-center built-in 4 in. indicator. Both gain and zero point are stabilized by a combination of a-c. amplification and d-c. null-balance feedback. Voltage amplifier can be used with sources up

to 10,000 ohms, and current type with sources of 100,000 ohms and higher. Basic range of voltage amplifier is 0 to 50 or -25 to 25 mv., with scale multipliers of 1, 2, 4, 10, 20 and 40; of current amplifier, 0 to 1000 or -500 to 500 uuamp. with multipliers of 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, and 2000. Response time of both models is 2 to 3 sec. Output at recorder connector for full-scale input on any range is 10 mv. at output impedance of 500 ohms.—*Leeds & Northrup Co.*, 4934 *Stenton Ave., Philadelphia* 44, *Pa.*

Mention No. 760 when filling out card.

Frequency Meter

New "FM-1" VHF frequency meter range is from 20 to 480 Mc. direct reading. Accuracy is 0.005 percent within range of 32 to 120 F. It is operated

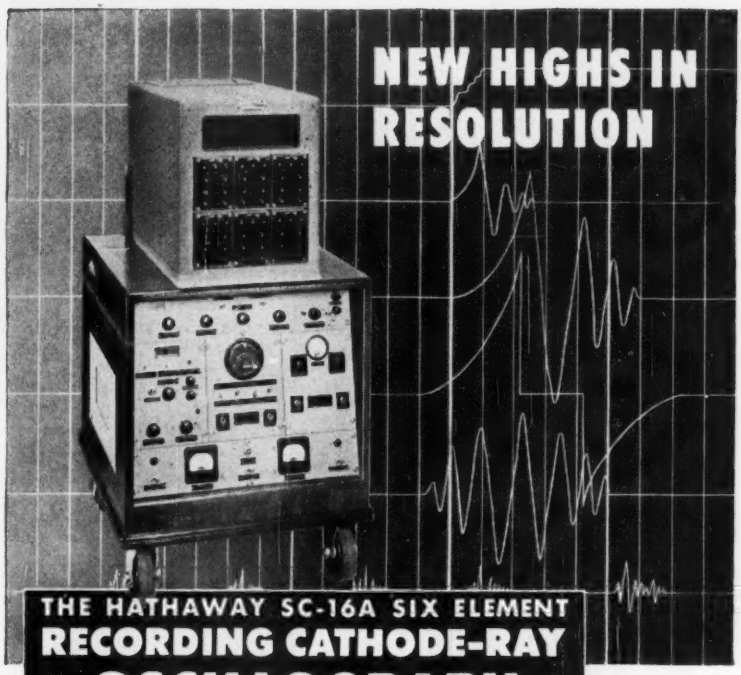


from dry batteries or from regulated laboratory power supply. Provision is made to modulate carrier approx. 30 percent at 1,000 cps. Weight is 20 lbs. —*Gertsch Products, Inc.*, 11,846 *Mississippi Ave., Los Angeles* 25, *Calif.*

Mention No. 761 when filling out card.

Wheatstone-megohm Bridge

New "635-A" Wheatstone-megohm bridge, designed for resistance measurements between 10 ohms and 1,000,000 megohms, is basically a Wheatstone bridge used in conjunction with a d-c. amplifier. Two built-in power supplies operating on 115 v., 60 cps. provide correct bridge voltages for high and



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NEW HIGHS IN RESOLUTION are obtained by this new oscillograph because of its unusually HIGH FREQUENCY RESPONSE and HIGH CHART SPEED...designed for recording fast transients and continuous phenomena.

FREQUENCY RESPONSE 0 to 200,000 cycles per second
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RECORDS up to 10 ft. long as speeds up to 6000 inches per second
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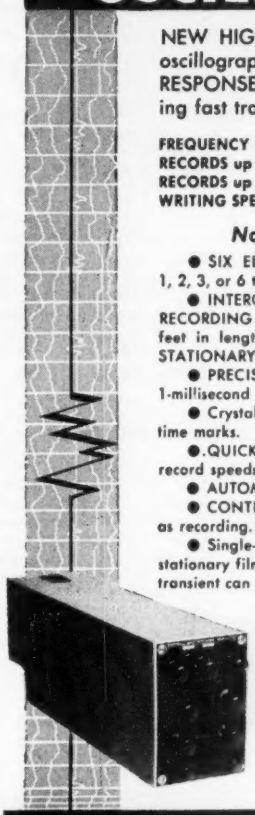
- INTERCHANGEABLE RECORD MAGAZINES for CONTINUOUS RECORDING on strip chart, either 6 inches or 35mm in width up to 1000 feet in length, DRUM RECORDING for short, high-speed records, and STATIONARY CHART for very short transients.
- PRECISION TIMING EQUIPMENT, tuning fork controlled, for 1-millisecond or 10-millisecond time lines.
- Crystal-controlled Z-AXIS MODULATION for 1/10 millisecond time marks.
- QUICK-CHANGE TRANSMISSION for instantaneous selection of 16 record speeds over a range of 120 to 1.
- AUTOMATIC INTENSITY CONTROL.
- CONTINUOUS SWEEP OSCILLATOR which permits viewing as well as recording.
- Single-pulse LINEAR OSCILLATOR for recording transients on stationary film. The record can initiate the transient to be recorded, or the transient can initiate the record.



Each recording element is a complete unit, fully housed, which can be instantly inserted or removed. Recording element contains high-intensity cathode-ray tube, and both AC and DC amplifiers. Control panel is located on outside end.

FOR FURTHER INFORMATION, WRITE FOR BULLETIN 2 G-1-H

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BURGESS BATTERY COMPANY FREEPORT, ILLINOIS

low ranges. A regulated supply is used on high ranges to counteract effects of dielectric absorption.—*Shallcross Mfg. Co., Collingdale, Pa.*

Mention No. 762 when filling out card.

Vacuum-tube Voltmeter

New "Type 1803-A" vacuum-tube voltmeter range is from 0.1 to 150 v. covered in 5 steps (1.5, 5, 15, 50, and 150 v., full scale). Accuracy is within

3 percent. Frequency error is 10 percent at 120 Mc. and correction curves are supplied, by means of which rated accuracy can be obtained up to 200 Mc. Indicator is peak indicating and is calibrated in rms. values of sinoidal voltage.—*General Radio Co., 275 Massachussetts Ave., Cambridge 39, Mass.*

Mention No. 763 when filling out card.

Hook-on Wattmeter

New "Type AK-2" hook-on wattmeter applicable to active and reactive power measurements in single-phase and polyphase circuits enables measurements to be taken without service interruption. Three-phase balanced-power measurement is made possible

by hook-on unit: accomplished by passing two power leads through hook, and connecting potential leads to same two power leads. Range is 3-300 Kw.—*General Electric Co., Schenectady 5, N.Y.*

Mention No. 764 when filling out card.

Megohmmeter

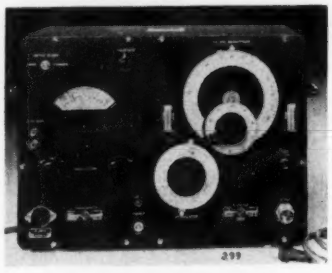
New "Major" megohmmeter employs a 500-v. d-c. slip-clutch generator to give a range of 0-50 megohms and infinity, and auxiliary scales measuring down to one-tenth ohm on a 0-30 scale

and down to 10 ohms on a 0-10,000 scale. Crankhandle speed is approximately 150 rpm. Case is of polished teakwood with rubber feet and protective metal flap over scale glass.—*Herman H. Sticht Co., Inc., 27 Park Place, New York, N. Y.*

Mention No. 765 when filling out card.

Standard-signal Generator

New "Type 1021-A" standard-signal generator for UHF and VHF bands between 50 and 250 Mc. and between 250 and 920 Mc. uses butterfly tuning elements and coaxial 50-ohm output



systems. Output range is from 0.5 microvolt to 1 volt, open circuit. Frequency dial is direct reading to 1 percent. Internal amplitude modulation at 1000 cps. is provided and external modulation between 30 cycles and 15 kc. can be applied.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

Mention No. 766 when filling out card.

D-c. Breaker Amplifier

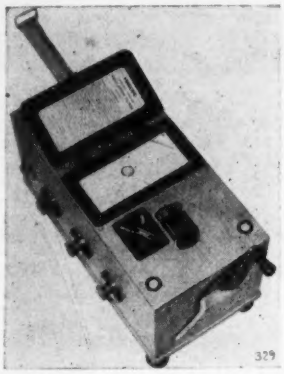
New "Model 10" ultrasensitive d-c. breaker amplifier is based on design by General Motors to measure d.c. in microvolt and fraction regions, thus being suitable for replacing high-sen-

sitivity galvanometers. An 8-cps. breaker frequency discriminates against 60-cps. hum. Drift is less than 0.005 microvolts per 8 hours. Gain control has 20 positions, 4 db per position, with 7 test signals ranging from 0.1 to 100 microvolts. Input is 20 and output 500 ohms.—*Liston-Folb, P. O. Box* 1334, *Stamford, Conn.*

Mention No. 767 when filling out card.

Insulation Tester

New high-range "Megger" insulation tester employs a 2.500-v. d-c. generator, hand cranked at 120 rpm., to deliver a potential, held constant by a centrifugal governer, which allows testing up to 50,000 megohms, or, with a special two-

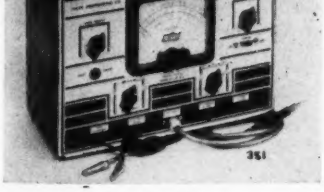


generator model, up to 100,000 megohms. Wide range is secured with overlapping scales giving a total length of 8.5 in. Instrument, especially useful in making dielectric-absorption tests, comes in teakwood case with window cover.—*James G. Biddle Co.,* 1316 *Arch St., Philadelphia* 7, *Pa.*

Mention No. 768 when filling out card.

Multi-purpose Electrical Tester

New "Model TS-9" TV volt-ohm-milliammeter has voltage ranges in a.c. and d.c. of 0-5-10-100-500-1000, db from minus 20 to 16, ohms from 0.2 to 1000



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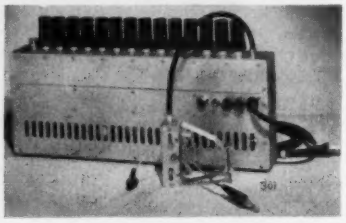
megohms in 5 steps, 0-1 ma., and a zero-center scale for FM and TV-discriminator alignment. Input impedance is 26 megohms on d.c. and 3 megohms on a.c.—*Feiler Engineering Co.*, 1601 *S. Federal St., Chicago, Ill.*

Mention No. 769 when filling out card.

Chain-pulse Amplifier

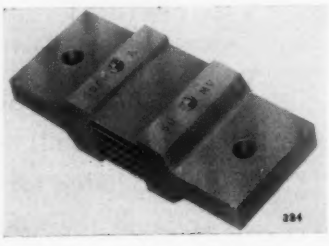
New "Model 214" chain-pulse amplifier, designed to amplify fast pulses and transients in a traveling-wave circuit, has a bandwidth of 40 kc. to 100 Mc. and a gain of 30 db. Input impedance is 180 ohms. A special termination at end of 15-in. cable is provided for convenient use with a cathode-ray tube for viewing high-speed pulses. With an output voltage of 65 and a rise time of 6 millimicroseconds, 1 in. deflection is obtained.—*Spencer-Kennedy Laboratories, Inc., Dept. I* 186 *Massachusetts Ave., Cambridge* 39, *Mass.*



Mention No. 770 when filling out card.

Switchboard Type Shunts

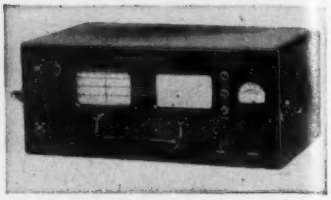
New external shunts for electrical instruments are offered in three styles and in 38 capacities from 10 to 20,000 amp. and with physical dimensions from 3.75 to 16.375 in. in length. Capacities below or above these valves are offered on special order. Lug blades are 0.25 in. thick and spaced 0.25 in. apart to receive 0.25 in. bus bar. Shunts can be furnished adjusted for 50, 75 or 100 mv. drop. Ring or multiple-range shunts can be supplied in any range combination within standard capacities.—*Cole Instrument Co.*, 1320 *S. Grand Ave., Los Angeles* 15, *Calif.*



Mention No. 771 when filling out card.

Radio Interference Locator

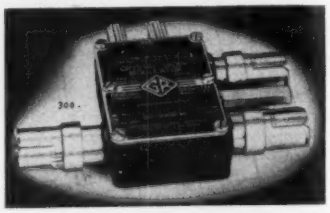
New "Model 302" locator for radio interference utilizes an 8-tube superheterodyne circuit and operates either from batteries or 115 v. mains. Range is 550 kc. to 30 Mc. Locator is supplied with both a loop and a collapsible-rod antenna. An R-F. search probe, insulated for 35,000 v. a.c., is available for field use as is an audio probe for circulating-current faults and cable-fault location.—*Sprague Products Co., N. Adams, Mass.*



Mention No. 772 when filling out card.

Diode Modulator

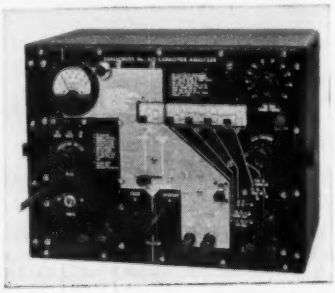
New "Type 1000-P6" crystal-diode modulator converts an oscillator, standard-signal generator, or other r-f. source into a test-signal generator for television-receiver testing. It modulates oscillator signal after attenuation, so that reaction on oscillator frequency is negligible. Range of modulating frequencies is 0 to 5 megacycles and carrier-frequency range is 20 to 1000 megacycles.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*



Mention No. 773 when filling out card.

Capacitor Analyzer

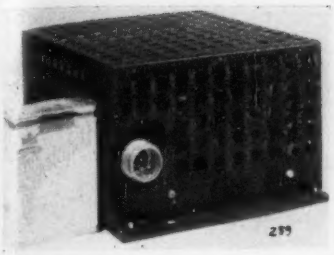
New laboratory-type capacitor analyzer will determine capacitance values between 5uuf. and 12,000 ufd.; insulation resistance from 1.1. to 12,000 megohms; also leakage current, dielectric strength, and percentage power factor. Analyzer operates on 110 v., 60-cps. supply.—*Shallcross Mfg. Co., Collingdale, Pa.*



Mention No. 774 when filling out card.

Phase Changer

New "Model 160" electronic phase adapter changes single-phase 115 v. 400 cps. current to three-phase 115 v. at 100 VA. Output voltage on all phases



is equal to input voltage within 3 percent over wide ranges of input voltage and frequency, load and power factor, temperature and altitude. It has no moving parts. Weight is 6.75 lbs. and volume 168 cu. in.—*Varo Mfg. Co., Garland, Texas.*

Mention No. 775 when filling out card.

Pocket Volt-ammeter

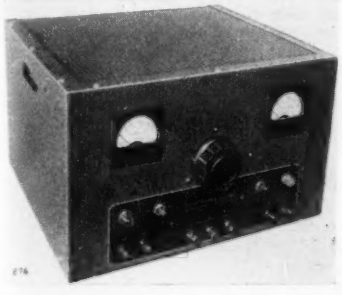
New "Model A-5-1" pocket-size volt-ammeter has seven ranges: 6.5-13-26-65-130 amp. and 150-600 v. Transformer core is permanently insulated with a

molded-plastic cover capable of withstanding 5,000 v.a.c.—*Pyramid Instrument Co., 49 Howard St., New York 13, N. Y.*

Mention No. 776 when filling out card.

High-voltage D-c. Supplies

New "Model 500BB" high-voltage supply is continuously adjustable between 0 and 500 v.d.c. and a 0-150 v., 5-ma. regulated bias supply is also available. A 6.3-v.a.c. 6-amp. center-tapped unregulated filament source has been provided. Regulation is within 0.5 percent for voltages between 30-500 from no load to full load and for line-voltage variations from 105-125 v. at full-load current between 30-500 v. output, and within 2 percent at 10 v.



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MODEL	READS	TOTALIZES	ACCURACY
S-100	1/5 sec.	6000 sec.	± .1 sec.
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SM-60	1/100 min.	60 min.	± .002 min.
S-10	1/10 sec.	1000 sec.	± .02 sec.
S-6	1/1000 min.	10 min.	± .0002 min.
S-1	1/100 sec.	60 sec.	± .01 sec.
MST	1/1000 sec.	.360 sec.	± .001 sec.
MST-500	1/1000 sec.	30 sec.	± .002 sec.

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STANDARDS

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WRITE FOR BULLETIN No. 602

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HEADQUARTERS FOR COLORIMETRIC APPARATUS

Hum is kept to within 10 mv. at any voltage or load within ratings.—*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Mention No. 777 when filling out card.

D-c. Power Supply

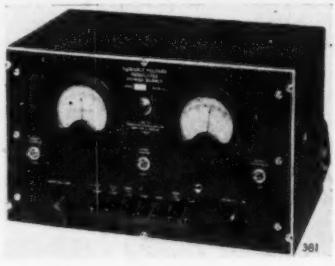
New d-c power supply has a selenium rectifier, full wave, six phase. A-c. input; 220 v., three phase, 60 cps., delivers d-c. 24 to 32 v., 30 amp. Supply is continuously variable from 24 to 32

v. by rheostat-control saturable reactor. Regulation: plus or minus 4 percent form 0 to full load. D-c. ripple: 1.5 percent. Ambient temperature: operates at 40 C., convection cooled. Speed of response: 0.4 sec.—*Richardson-Allen Corp., 15 W. 20th St., New York, N. Y.*

Mention No. 778 when filling out card.

Regulated Power Supply

New "Model A3" regulated power supply features continuously-variable d-c. voltage output from 0 to 400 with 0.5-percent regulation at loads from 0



to 200 ma. Other outputs are: 400 v. d.c. unregulated, 0 to 150 v. d.c. variable and stabilized, and 6.3 v. a.c. at 5 amp. Output-ripple voltage is less than 10 mv. Output impedance less than 10 ohms d.c., and less than 2 ohms from 20 cps. to 50 kc.—*Oregon Electronic Mfg. Co., 206 Washington St., Portland 4, Oregon.*

Mention No. 779 when filling out card.

D-c. Power Supply

New "Model BJ Junior" source of filtered d.c. supplies 1 to 12.5 amp., 6 v., continuous duty, with an intermittent rating up to 25 amps. and 3 to 9 v. at other ratings, operating from 115 volts, 50-60 cps. power source. Ripple is less than 0.4 v. at 6 v. d.c.,

8 amp.—*Electro Products Labs, Inc., 4501 N. Ravenswood Ave., Chicago 40, Ill.*

Mention No. 780 when filling out card.

Portable Ultraviolet Lamp

New "SL Series" of ultraviolet lights are available in both 2537 and 3660-Angstrom ranges. Their length is 10.5 in., and may be used with 110-v. a.c.

or d.c., or with 45-v. batteries. Weight is 1 lb. Five styles of carrying cases for lamps and batteries are available. —*Stratex Instrument Co., 1861 Hillhurst Ave., Los Angeles 27, Calif.*

Mention No. 781 when filling out card.

Pocket Telescope

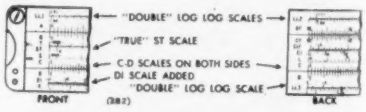
New "Penscope" pocket telescope is 5 in. long, weighs 2 oz., offers six-power

magnification and a field of view of 315 feet at 1000 yards.—*Pan-technics, Ltd., Encinitas, Calif.*

Mention No. 782 when filling out card.

Log Log Slide Rule

New "Model 500" 5-inch log log all-metal slide rule, bearing identical scales of its larger 10-inch counterpart, is



1.094 by 6 by 0.094 in. in size, and weighs 2 oz. It comes in leather pocket case slip-boxed with manual.—*Pickett & Eckel, Inc., 5 S. Wabash Ave., Chicago 3, Ill.*

Mention No. 783 when filling out card.

Plotting Table

New plotting table registers positions of x and y coordinates of a plane on Veeder-Root-type counters to nearest 0.001 in. Special designs are available calibrated in metric units. X and Y

carriages are positioned to better than 0.0002 in. Rapid movement is attained with a disengaging latch, while close adjustments are made with hand cranks.—*West Coast Div., Fairchild Camera & Instrument Corp., 53 W. Union St., Pasadena 1, Calif.*

Mention No. 784 when filling out card.

Panel Engraving Instrument

New pantograph engraving instrument designed specifically for marking and engraving control panels and other large assemblies produces fine engraved letters, numbers or designs on plastic, metal or wood surfaces by tracing master copy. Panels 0.375 in. thick by 19 in. wide by any length may be engraved. —*Green Instrument Co., 385 Putnam Ave., Cambridge, Mass.*

Mention No. 785 when filling out card.

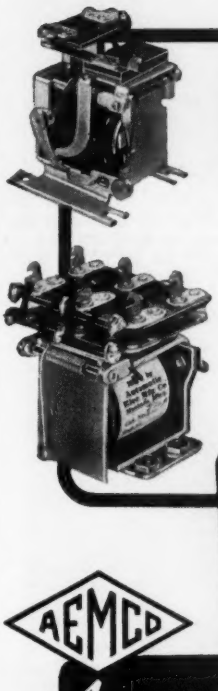
UV Source for Oil Prospecting

New "SL 3660 Mineralight" UV lamp operates from 110 v. a.c. or d.c. or from two 45-v. batteries. Long wavelength makes light especially useful in oil prospecting. Unit is available with special case for daylight examination of samples and for carrying batteries. —*Ultra-Violet Products, Inc., 145 Pasadena Ave., S. Pasadena, Calif.*

Mention No. 786 when filling out card.

Mercury Battery

New "RM-1C" mercury battery, at a current drain of 250 ma., has a service life approximately 10 hours, depending upon minimum voltage. Unit has an extremely constant voltage dis-



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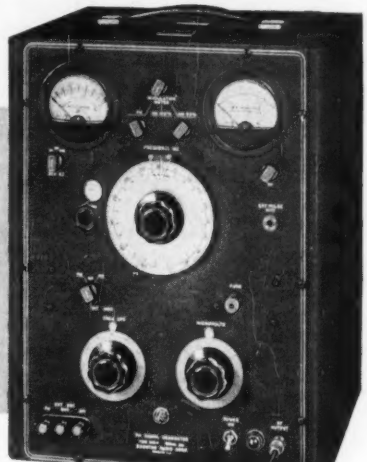

The Type 202-D Signal Generator is a precise and reliable instrument well suited to the specialized requirements of telemetering engineers for rapidly analyzing and evaluating overall system performance.

SPECIFICATIONS

RF RANGE: 175-250 megacycles, accurate to ± 0.5%. Main frequency dial also calibrated in 24 equal divisions for use with vernier frequency dial.

FREQUENCY MODULATION (Deviation): FM deviation continuously variable from zero to 240 kc. Modulation meter calibrated in three FM ranges: 0-24 kc., 0-80 kc., and 0-240 kc.

AMPLITUDE MODULATION: Utilizing the internal audio oscillator amplitude modulation may be obtained over the range of 0-50%, with meter calibration points at 30% and 50%. By means of an external audio oscillator the RF carrier may be amplitude modulated to substantially 100%.

RF OUTPUT VOLTAGE: The RF output voltage is continuously variable from 0.1 microvolt to 0.2 volt at the terminals of the output cable; Output impedance at front panel jack is 53 ohms resistive.

DISTORTION: The overall FM distortion at 75 kc deviation is less than 2% and at 240 kc. less than 10%. The AM distortion at 50% is less than 6.5%.

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charge rate, long shelf life and resistance to extremes of temperature, pressure, shock and humidity.—*Battery Div., P. R. Mallory & Co., Inc., N. Tarrytown, N. Y.*

Mention No. 787 when filling out card.

Shop Microscope

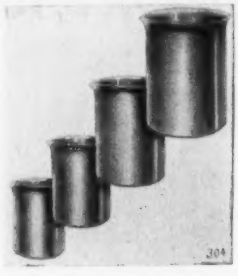
New "Model S-186" industrial 20-power microscope may be angled in any direction and raised and lowered to accommodate pieces up to 12 in. high. Fine-focus adjustment is obtained by

means of a built-in, helical-focusing eyepiece. Objective is interchangeable with any standard microscope objectives.—*Buhl Optical Co.*, 1009 *Beech Ave., Pittsburgh* 12, *Pa.*

Mention No. 788 when filling out card.

Stainless-steel Beakers

New line of beakers from 50 to 4000 cc. are made of 18-8 stainless steel.—

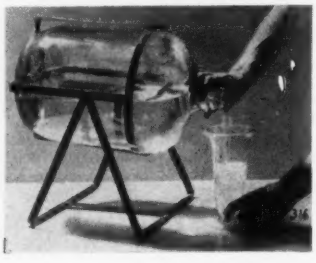


Arthur S. LaPine & Co., 121 *W. Hubbard St., Chicago, Ill.*

Mention No. 789 when filling out card.

Safety Pourer for Acids

New "GS" tilter for 5-gallon bottles provides a safe and easy method of

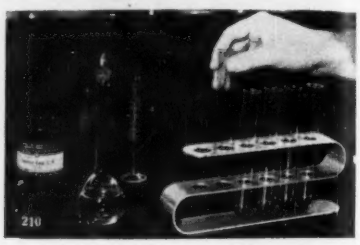


pouring liquids into smaller containers.—*General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa.*

Mention No. 790 when filling out card.

Test-tube Rack

New test-tube rack consists of a single piece of anodized-aluminum sheeting, drilled to accommodate up to six

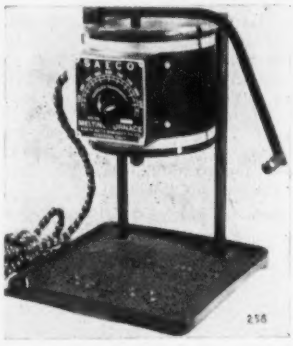


test tubes of 4 in. height or more, and up to 0.875 in. dia.—*Fisher Scientific Co.*, 717 *Forbes St., Pittsburgh* 19, *Pa.*

Mention No. 791 when filling out card.

Bench-type Melting Furnace

New "Saeco" electric melting furnace has thermostatic heat control to maintain a temperature within 20 F. over range 450 to 850 F. Insulation is spun



glass; pre-heating time is 10 to 15 min.; power consumed is 1000 watts at 115 v.—*Santa Anita Engineering Co.*, 2435 *E. Colorado St., Pasadena* 1, *Calif.*

Mention No. 792 when filling out card.

Hand Torch

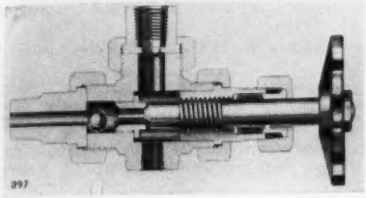
New "Prepo" portable torch of interest to instrument users uses nontoxic low-pressure hydrocarbon fuel

which is self pressurizing. Torch is available with broad and pin-point flame heads.—*Pressure Products Corp., 140 N. Dearborn St., Chicago 2, Ill.*

Mention No. 793 when filling out card.

Gage Valves

New double-union gage valves make it possible to turn gage in any desired angle or to remove it from operation

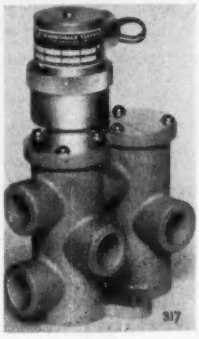


without removing valves or draining vessel.—*Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.*

Mention No. 794 when filling out card.

Four-way Solenoid Valves

New "Crescent" 4-way solenoid valves are available for control of air, water, and light oil up to 150 psi., in pipe sizes of 0.25, 0.375, 0.5 and 0.75

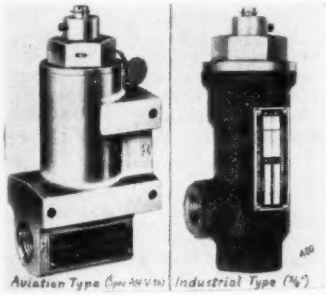


in. pipe size. Solenoids are of special design to withstand continuous operation up to 600 cycles a minute. Records are said to show several million cycles without maintenance.—*Barksdale Valves, 4905 Santa Fe Avenue, Los Angeles 58, Calif.*

Mention No. 795 when filling out card.

Relief Valves

New cartridge-type hydraulic relief valves offer new design possibilities for industry. Available for pressure settings ranging from 100 to 5,000 psi.,



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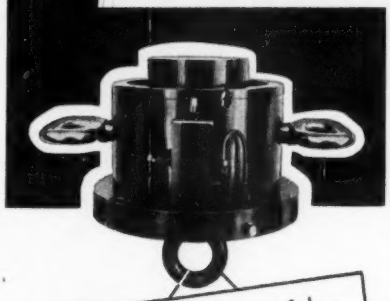

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valve opens and closes within a 7 percent differential. Valve has been tested through temperature variations ranging from —65 to 160 F. with no more than a 5 percent change in operating characteristics. Operating mechanism is contained in a cartridge so designed that it may be replaced without breaking line.—*Hydraulics Div., Pantex Mfg. Corp., Pawtucket, R. I.*

Mention No. 796 when filling out card.

Automatic-reseat Relief Valve

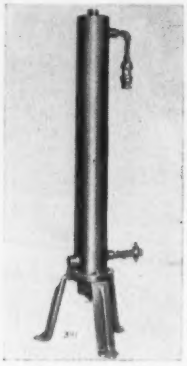
New automatic-reseating temperature and pressure relief valve features a

bellows assembly above water level to forestall liming.—*A. W. Cash Valve Mfg. Corp., Wabash and Morgan, Decatur 60, Ill.*

Mention No. 797 when filling out card.

Compressed-air Cooling Unit

New "Type V-907" aftercooler for compressed air comes in two sizes. Smaller size measures 30 in. over-all, with legs as shown, and cools up to 20

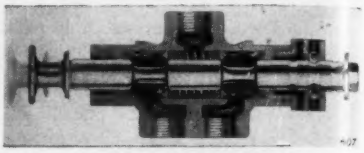


cfm. Larger size measures 48 in. over-all and cools 30 to 50 cfm. Air inlet and outlet pipe sizes up to 1 in. may be specified.—*Jas. A. Murphy & Co., Inc., 5th and Vine St., Hamilton, Ohio.*

Mention No. 798 when filling out card.

Air Valve for "Hold-position" Applications

New line of air valves have all ports blocked in neutral position, making it possible to stop and hold piston of a single- or double-acting cylinder in any

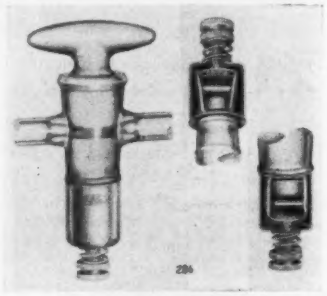


position. Valve may be supplied to operate with knob, lever, clevis, or treadle, in 0.25, 0.375, 0.5, 0.75, or 1 in. pipe sizes. Pressure range is 0 to 175 psi.—*Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.*

Mention No. 799 when filling out card.

Universal Stopcock Adapter

New universal stopcock adapter eliminates leaking stopcocks up to 4 mm.

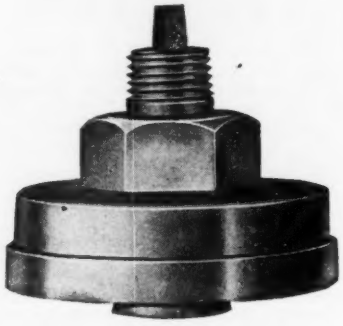


bore. It is made of corrosion-resistant materials.—*Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

Mention No. 800 when filling out card.

Air-line Moisture Eliminator

New "Drain Master" pet cock automatically ejects moisture and oil from air-line traps, compressors, etc. It is 2



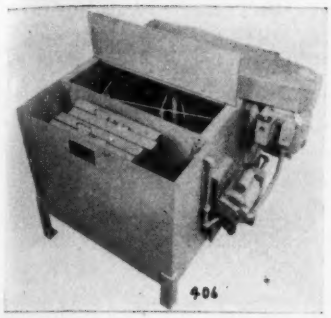
(ACTUAL SIZE)

in. high and weighs 3.5 oz. One model is designed for automotive air-brake systems and the other for industrial applications.—*Master Equipment Corp., 15 N. Broadway, Dayton, Ohio.*

Mention No. 801 when filling out card.

Air-filter Washer

New "Far-Air" utility washing and oiling machine for viscous-impingement panel-type air filters up to 20 by 28 by

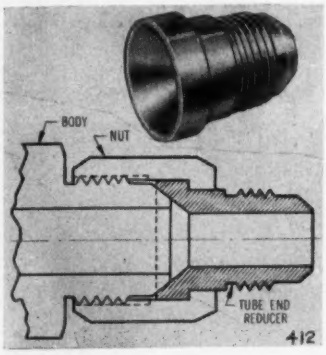


4 in. is said to reduce maintenance costs as much as 67 percent.—*Farr Co., Los Angeles* 43, *Calif.*

Mention No. 802 when filling out card.

Tubing Reducer

New tube-end reducer for use with maker's "Triple-lok" fittings to step

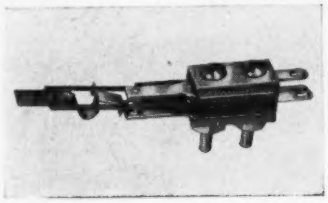


down to smaller tube sizes is available in eight sizes up to 0.75 in.—*Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

Mention No. 803 when filling out card.

Snap-action Switch

New snap-action switch is adjustable to operating movement and overtravel. Main operating blade, of tempered spring steel, can be furnished to



operate at various pressures. Switch can be used for s-p. s-t or s-p. d-t requirements. Special types are available. Unit weighs about one oz.—*Comar Electric Co.*, 3148 *N. Washtenaw Ave., Chicago* 18, *Ill.*

Mention No. 804 when filling out card.

Precision Switch

New "Type MX-1-Z25" snap-acting precision switch gives a variable-differential motion which may be fixed anywhere within range 0.0005 to 0.008

—1,000 to 200,000 Ft. Full Range 0 to 790 mm. Hg.
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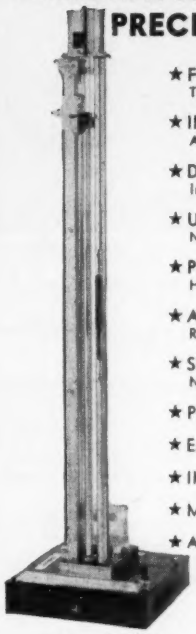

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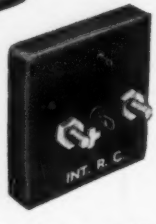

Rear View Type DP-5.

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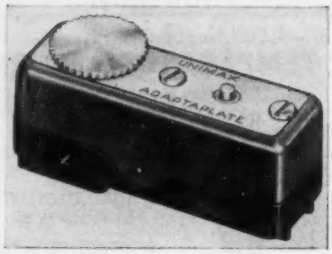
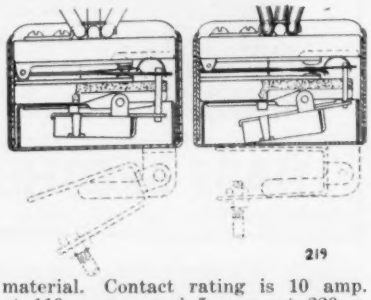


in. Knurled knob permits easy adjustment to compensate for variations in working tolerances during operation.—*Unimax Switch Div., W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.*

Mention No. 805 when filling out card.

Magnetic Proximity Switch

New magnetic proximity switch obtains positive snap action through use of an Alnico permanent magnet actuated by an armature of magnetic



material. Contact rating is 10 amp. at 110 v. a.c., and 5 amp. at 220 v. a.c., underwriters approved. Switches may be had for temperatures up to 175, 250, or 400 F. depending on method of sealing and pigtail insulation.—*Jo-Bell Products Co., Inc., 4840 S. St. Louis Ave., Chicago, Ill.*

Mention No. 806 when filling out card.

Rotary Snap Switch

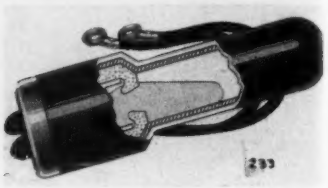
New "Series No. 2800" rotary snap switch is available in a wide variety of circuit sequences. Switch is rated

at 15 amp., 125 v. a.c. Over-all dimensions of switch body are 1.75 by 1.375 by 0.75 in.—*Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.*

Mention No. 807 when filling out card.

Mercury Switches

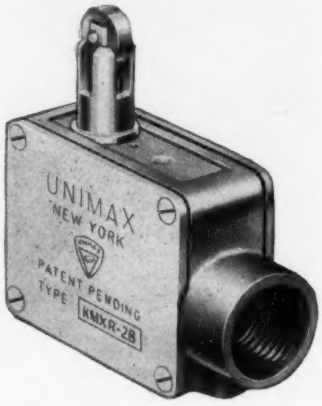
New models of maker's mercury switches are improved by use of specially-prepared mercury. Several advantages are lower contact resistance and cooler operation.—*Durakool, Inc., Elkhart, Ind.*



Mention No. 808 when filling out card.

Precision Switch

New "Type KMXR" switch incorporates a free-turning stainless-steel roller in top of a spring plunger capable of absorbing up to 0.219 in. of movement beyond actuating point of

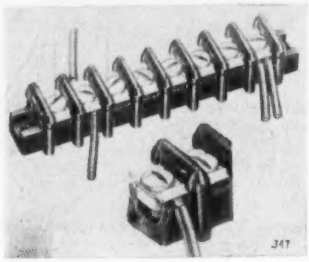


switch. S-p.d-t. switch rated at 15 amp. 110-125-v. 60 cps. is readily removed for making electric-wiring connections. Gasketed side plates seal housing, making it splash-proof.—*Unimax Switch Div., The W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.*

Mention No. 809 when filling out card.

Terminal Block

New "Type E" terminal block is for use with small wires: max. of AWG 18



stranded and 16 solid.—*Curtis Development & Mfg. Co., 3266 N. 33rd St., Milwaukee 16, Wis.*

Mention No. 810 when filling out card.

Wire-labeling Strips

New heat-resistant wire marker that withstands temperature of 400 F. is also resistant to solvents. Marker features a thermo-setting bonding agent,

combined with a heat-resistant glass-cloth backing material and a dielectric strength of 1800 and an electrolytic corrosion factor of 0.95.—*E-Z Code Div., Western Lithograph Co.*, 604 *E. Second St., Los Angeles* 54, *Calif.*

Mention No. 811 when filling out card.

Labeling Tape

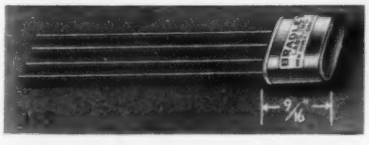
New smudge-proof labeling tape is water proof, oil proof, acid resistant, and will stand up to 150 F. It is made

in 0.625 or 0.75 in. sizes of two sheets of acetate with special carbon material between.—*Labelon Tape Co.*, 100 *Anderson Ave., Rochester, N. Y.*

Mention No. 812 when filling out card.

Copper-oxide Rectifiers

New "Model CX3" hermetically-sealed copper-oxide rectifiers are rated



up to 6 v. a.c. and 5 ma. d.c. Sealed container is 0.688 in. by 0.561 in. high by 0.25 in deep.—*Bradley Laboratories, Inc.*, 82 *Meadow St., New Haven, Conn.*

Mention No. 813 when filling out card.

Pilot Light

New "Omni-Glow" ready-to-install neon-type pilot light for instrument and other panels, is completely enclosed in a plastic case, mounts through a half-inch hole. Maximum extension behind panel is 1.5 in. For high temperature applications, a special nylon housing is available. Standard coloring is

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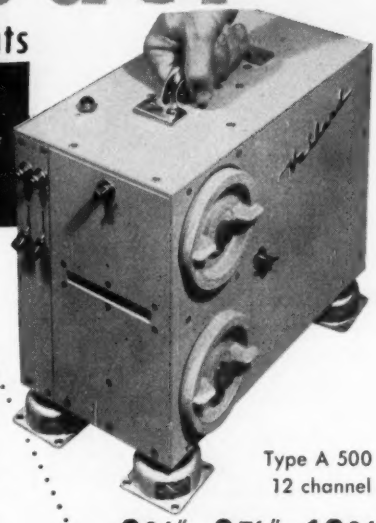

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In this instrument—designed for measurement of very low light values—S.S.White Resistors serve as the grid resistance in the all-important high-gain D.C. amplifier circuit. The manufacturer, Photovolt Corp., New York, N. Y., reports that the resistors "work very satisfactorily"—which checks with the experience of the many other electronic equipment manufacturers who use S.S.White resistors.

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It gives essential data about S.S.White Resistors, including construction, characteristics, dimensions, etc. Copy with price list on request.

Photo courtesy of Photovolt Corp., New York, N. Y.

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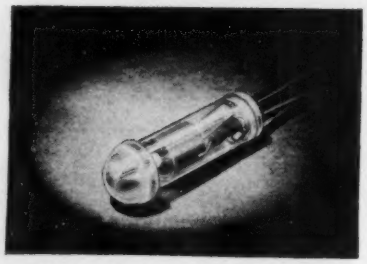


red; other colors suitable for neon illumination available.—*Industrial Devices, Inc., Edgewater, N. J.*

Mention No. 814 when filling out card.

Gas Torch

New "LP" gas torch operates most efficiently on propane and will give a flame up to 3660 F. Weight loaded is less than 2.5 lb.—*Otto Bernz Co., Inc., 280 Lyell Ave., Rochester 6, N. Y.*

Mention No. 815 when filling out card.

Alcohol Blow Torch

New "No. 2-4769" blow torch will operate in any position and deliver a flame over 2700 F. Windshield is provided for outdoor use.—*Arthur S. LaPine & Co., 121 W. Hubbard St., Chicago 10, Ill.*

Mention No. 816 when filling out card.

Tools for Ball Bearings

New hand tools for assembling ball bearings into equipment provide visual means for aligning bearing with apparatus and provide feel for precise fits. Tools are available for radial bearings down to three-sixteenths in. and for some pivot bearings.—*The Baker Co., Maplewood, Maine.*

Mention No. 817 when filling out card.

Miniature Capacitors

New "Type P83Z" capacitors measure 0.1875 dia. by 0.4375 in. long. Metalized dielectric provides both dielectric and electrodes. Operating temperatures range from 15 C. to 85 C. without derating. Power factor is less than 1 percent when measured at or referred to a frequency of 1000 cps. and an ambient temperature of 25 C. Self inductance is not greater than equivalent length of wire.—*Aerovox Corp., New Bedford, Mass.*

Mention No. 818 when filling out card.

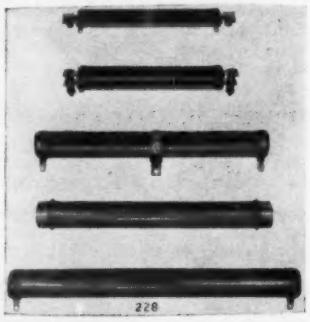
Potential Dividers

New "Type RVC2", potential dividers have nesting bases rotatable for accurate phasing. New feature is crank arm spring-loaded to eliminate backlash: a single unit may be removed without disturbing adjustment or phasing of others in assembly.—*Technology Instrument Corp., 1058 Main St., Waltham 54, Mass.*

Mention No. 819 when filling out card.

Resistors

New improvements in resistors illustrated are in stronger ceramic cores, new uniform winding, corrosion-proof terminals, and a new crazeless, thermoshock proof, blue-gray vitreous-enamel coating.—*Hardwick-Hindle Inc., Newark 5, N. J.*



Mention No. 820 when filling out card.

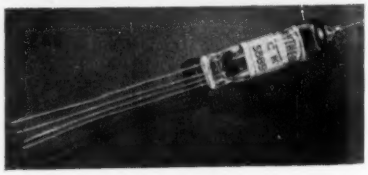
Special Coils and Chokes

New line of coils and chokes adaptable to "tailor-made" specifications includes high-Q r-f. chokes, progressively-wound slug-tuned broadcast and oscillator coils. Chokes may be made up as two coils having a specified coupling coefficient.—*Shalleross Mfg. Co., Collingdale, Pa.*

Mention No. 821 when filling out card.

Subminiature Electrometer Pentode

New "CK5889" subminiature electrometer pentode has a 7.5 ma. low-microphonic filament; double-ended construction and a guard ring. Grid current is of the order of 0.001 micromicroamperes. In single-stage type of circuit, tube has sufficient reserve emission to provide operation for several thousand hours.—*Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass.*



Mention No. 822 when filling out card.

Double-triode Subminiature Tube

New subminiature tube, available with pigtail leads as "type 6BF7," and with short pins for socketing as "type 6BG7," is supplied in a T-3 buib measuring only 0.400 in. diameter and 1.5 in. long. Tubes are supplied with separate cathodes for each triode section. Transconductance is 4800 micromhos; amplification factor per triode section of 35 when 100 v. is used on plates; max. plate dissipation per section of 1.0 watt; grid-to-plate capacitance per section of 1.5, input capacitance per plate of 2.0 and output of 1.0 micromicrofarads.—*Sylvania Electric Products Inc.*, 500 *Fifth Ave., New York* 18, *N. Y.*

Mention No. 823 when filling out card.

Oscilloscope Tube

New "7MP7" seven-inch cathode-ray tube of magnetic-deflection and magnetic-focus type having a long-persistence, cascade (two-layer) screen is intended primarily for pulse-modulated

applications, such as radar indicator service, and replaces "7BP7-A" in new equipment design.—*Tube Department, Radio Corporation of America, Harrison, N. J.*

Mention No. 824 When filling out card.

Full-wave Heater-cathode Rectifier

New "Type 6AX5GT" heater-cathode rectifier requires same heating time as other tubes which prevents excessive voltage across filter capacitors that often occur during warmup when filamentary-type rectifiers are used.—*Radio Tube Div., Sylvania Electric Products Inc.*, 500 *Fifth Ave., New York* 18, *N. Y.*

Mention No. 825 when filling out card.

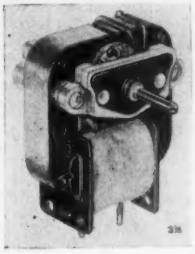
Low-current Selenium Rectifier

New "Model SE8LA" low-current selenium rectifier features a special plate for use on direct currents in microampere region. Unit is rated up to 6,000 v. peak inverse and can be connected in series for higher voltages. It has been developed for such equipment as radioactivity counters and cathode-ray tubes.—*Bradley Labs.*, 82 *Meadow St., New Haven, Conn.*

Mention No. 826 when filling out card.

Fractional-hp. Motor

New "Type 230" fractional-horsepower motor with a uniform air gap



around stator, has ratings from 0.005 to 0.02 hp.—*Raytheon Mfg. Co., Motor Div., Russell Electric Co., Chicago, Ill.*

Mention No. 827 when filling out card.

Tubular Capacitors

New "Type P123ZG Aerolite" capacitors have metallized-paper section Hyvol-K or M impregnated and placed in a nonmagnetic hermetically-sealed metal case with vitrified-ceramic terminal seals. Operating temperatures range from -55 to 50 C. without derating, and up to 95 C. with voltage derating. Units are available in 200, 400 and 600-v.d.c. and capacitance values of 0.0005 to 2.0 ufd.—*Aerovox Corp., New Bedford, Mass.*

Mention No. 828 when filling out card.

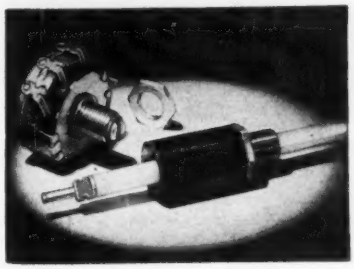
Bakelite-cased Capacitors

New "Type ETW" electrolytic motor-starting capacitor is 1.436 in. dia. and 2.75 in. long. Available in capacities up to 150 ufd. at 110-v.a.c., it can be used whenever starting cycle does not exceed 60 one-second starts per hour or its equivalent. Unit can be operated at temperatures up to 65 C.—*Corneu-Dubilier Elec. Corp., South Plainfield, N. J.*

Mention No. 829 when filling out card.

High-voltage Coupler

New "Types AM and AT" high-voltage coupler has high-voltage insulator sleeve which screws on to control bushing while threaded metal-stud



end takes mounting nut. Nylon shaft with keyed end slips into control slot. Coupler is rated at 10,000 v. breakdown test.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

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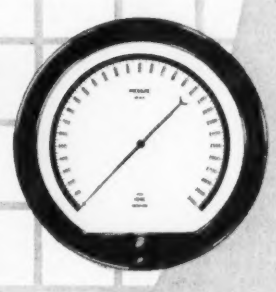
one-second zero setting with revolving dial and external knob



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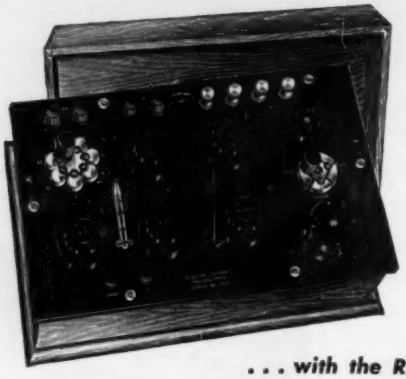

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- Sub-panel switch construction
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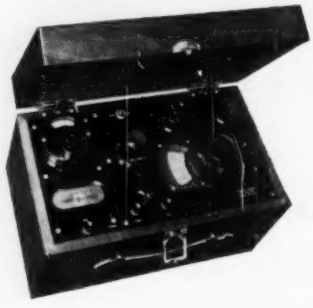
Described in Bulletin 100



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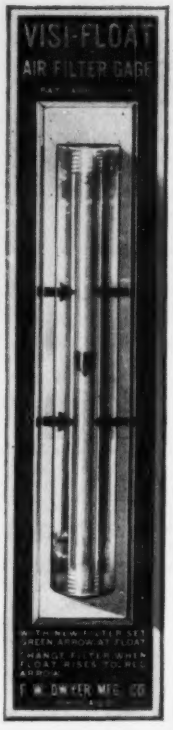

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VOL. 6 JULY 1950 NO. 7

1950 Buffalo Instrument Exhibit a Sell Out

The Fifth National Instrument Exhibit, sponsored by the Instrument Society of America, has been completely sold out.

The exhibit, to be held in the Memorial Auditorium in Buffalo, New York, this September, was originally planned to accommodate 165 booths each 10 ft. wide and with varying depths of 8, 10 and 12 ft. These 165 booths were quickly reserved.

To meet a persistent demand, 16 additional booths were made available. This first addition of 16 booths has been reserved so quickly—11 have already been taken—that 10 MORE BOOTHS have been added to satisfy the demand.

This is the first time in its history that the Instrument Exhibit has been a complete sell out so far in advance of the opening of the Show. The opening date is about 60 days away. It is the first time that the size of the Exhibit has been so greatly expanded over early plans. Present indications point toward an exhibit of 191 booths.

This is a definite sign that the immense value of the Instrument Exhibit is being more fully realized. Attendance at the Show is expected to exceed 8000. The Show will open on Monday, September 18, 1950 in the Memorial Auditorium in Buffalo, New York and run until Friday, September 22.

Instrumentation Flow Plan Symbols

ISA Tentative Recommended Practice RP5.1, "Instrumentation Flow Plan Symbols" is now being mailed to all ISA members. This Recommended Practice, distributed as a part of the service of the Instrument Society of America toward a goal of uniformity in the field of Instrumentation, has been prepared by the Sub-Committee on Instrumentation Flow Plan Symbols of the Main Recommended Practices Committee. Members of the Sub-Committee who prepared the report are: D. E. Hostedler, Sub-Committee Chairman, Foster Wheeler Corp.; J. H. Cope, Hydrocarbon Research Corp.; F. L. Crabbe, Malcolm W. Black & Co.; H. E. Hanson, Standard Oil Development Co.; E. R. Huckman, The Foxboro Co.; H. A. Irving, Taylor Instrument Companies; M. MacDonald, M. W. Kellogg Co.; S. D. Ross, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.

The report was prepared to provide a satisfactory system of symbols and identifications for industrial process instrumentation equipment and to designate and identify such equipment on flow plans and in other requirements. The purpose of the report is to promote a uniformity of practice that will simplify and expedite instrumentation work. The system presented is to designate and identify instrumentation on flow plans; for recording in specifications, listings, requisitions, and order sheets; to indicate items on piping and other construction drawings; for identification tagging of equipment; and for use in technical and trade literature and drawings.

The system of symbols and identifications is the result of an extensive survey of the subject. It is a consolidation of the best ideas and usual practice in systems now being used. The Sub-Committee first drafted a "suggested" system based on knowledge of existing systems. This, with a questionnaire, was sent to 352 individuals and organizations who use such symbols in their regular work. A total of 142 replies were received from a wide list of industries and geographical areas. The information received from the survey was utilized in modifying and correcting the "suggested" system.

The instrumentation symbols and identifications presented are suited primarily to the needs of the industrial process industries. Within this field it is intended that the system should be capable of designating and identifying the multitude of instruments and instrumentation items which are used for control and operation of the processes and for obtaining data on their performance. Although not designed primarily for their requirements, the system should be adequate for use by all allied industries such as steam generation, fluid materials handling, air conditioning, etc., since the applications are much the same and many of the instruments identical and since even those items differing in detail of construction are alike in principle and can be designated by the same symbols.

This Tentative Recommended Practice contains 7 pages of recommended symbols with 2 tables of letter identifications. The complete report is 14 pages.

Quantity prices of copies of RP5.1 are as follows: up to 20 copies—$1.00 ea.; 21-50 copies 50 cents ea.; 51-100 copies 30 cents ea.; 101 or more copies 25 cents ea. Obtainable from the ISA National Office, 921 Ridge Avenue, Pittsburgh 12, Pa.

Summary of Miles Traveled by Those Attending ISA Meeting in St. Louis, September 12-16, 1949*

EXHIBITORS

890 men traveled an average of 627.2 miles to St. Louis Meeting or a total of 558,228 "man miles."
99 men traveled 50 miles or less to St. Louis meeting

989 Total number of men attending

INDUSTRY

1474 men traveled an average of 493.7 miles to St. Louis Meeting or a total of 727,757 "man miles."
2110 men traveled 50 miles or less to St. Louis Meeting

3584 Total number of men attending

EDUCATIONAL GROUP

129 men traveled an average of 354.5 miles to St. Louis Meeting or a total of 45,735 "man miles."
207 men traveled 50 miles or less to St. Louis Meeting

336 Total number of men attending

NOTE: There were a number of people at the St. Louis Meeting who came from foreign countries. These were not taken into consideration in the above figures; they numbered 49 and came from such countries as Argentina, Australia, Belgium, Canada, England, Indonesia, Italy, Mexico, Netherlands, Sweden, Switzerland, West Indies. Of these, two came as exhibitors, one from Belgium, the other from Montreal, Canada. The remaining 47 attending from foreign countries were non-exhibitors.

*This summary was prepared by Porter Hart, Vice-President, Operations, ISA.

ISA EMPLOYMENT REGISTER

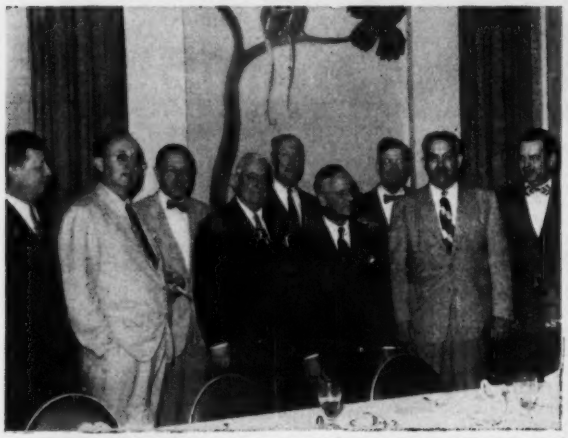
Fifth Annual Instrument Conference and Exhibit, Memorial Auditorium, Buffalo, New York September 18-22, 1950

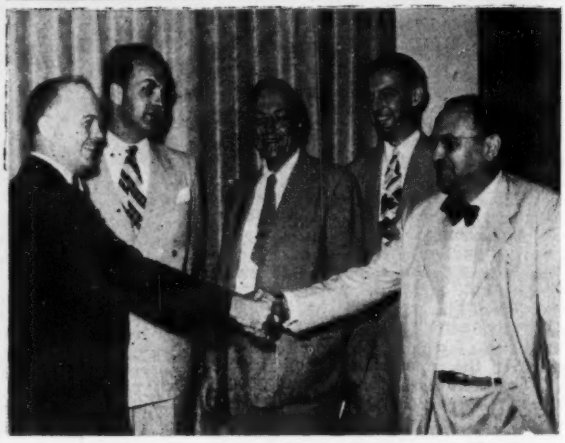
Seeking a Position in Instrumentation? Registration forms and further instructions may be obtained from the Society Office. Registration by applicants may be made by mail to this office prior to opening of the Conference and Exhibit or may be made in person Sept. 18-22 at the Employment Register Desk, Memorial Auditorium. You do not have to be present. Prospective Employers may examine applications and make selection for mail or personal contact. Write now for application card.

Do You Need an Instrument Man? Companies or institutions seeking instrument men are requested to file notice of open positions prior to the week of the Conference and Exhibit for posting on bulletin board. You do not have to be present. Interested applicants will be instructed to write direct to you.

Interviews Arranged. Representatives of employers and applicants attending the Conference and Exhibit are urged to register at the **Employment Register** immediately upon arrival so that interviews may be arranged. **THE INSTRUMENT SOCIETY OF AMERICA, 921 Ridge Avenue, Pittsburgh 12, Pa.**

'51 SHOW ANNOUNCEMENT LUNCHEON





Top (left to right): C. E. Naylor, Porter Hart, R. J. S. Pigott, Hon. J. S. Griffith (Houston City Council), Dr. William Houston (Pres. Rice Institute), Dr. A. P. Beutel (Vice-Pres. Dow Chemical Co.), Hines Baker (Pres. Humble Oil & Refining Co.), J. B. McMahon and W. Fortney. Pres. Pigott talking to Drs. G. L. Farrar and P. G. Murdoch.

Bottom (left to right): Harold Tellepson (Pres. Tellepson Construction Co.), N. Gildersleeve, N. D. Griswold (Asst. Gen. Mgr. Dow Chemical Co.), Lyman Allen, Jr., and Richard Rimbach.

About 80 leading industrial executives in the Gulf Coast region attended a luncheon in the South American Room, Rice Hotel, Houston, June 20th, 1950. The sponsoring Committee was made up of the following: Chairman C. E. Naylor, President, Maintenance Engineering Corp.; Hines H. Baker, President, Humble Oil & Refining Co.; Dr. A. P. Beutel, Vice President, Dow Chemical Co.; J. R. Mares, Vice President, Monsanto Chemical Co.; and Joseph H. Russell, Vice President, Gulf Oil Corp.

*Extract from the Introduction by C. E. Naylor**

Many of those in management positions little realize what a great part the science of instrumentation has contributed towards the success and efficiency of modern industrial plants. It is, therefore, very fitting that we have such a fine gathering of distinguished business leaders and those in industrial key positions as a compliment to the local members of the Instrument Society of America. It is fitting that we pay tribute to the members of the Instrument Society of America, an organization making tangible returns to industry by their work in promoting standards, training programs, and exchange of ideas.

It is now my pleasure to introduce a gentleman who heads up the local committee for the 1951 Instrument Society of America Conference and Exhibit which is to be held in Houston in September of next year. He is not only an outstanding man in his work as an instrument technician, he is also active in civic affairs in the City of Baytown. He was born in Arkansas which reminds me of a story having to do with the early settlers to the southwest who came from Kentucky, Tennessee and Virginia—In those days, near Shreveport there was a big sign which read "This Way to Texas". Those that could read came on to Texas, the others went to Arkansas. "Mac" Fortney deserves a lot of credit because just as soon as he learned to read, he moved to Texas. Fortney was the moving spirit in founding the Houston Chapter of the Instrument Society of America and served

C. E. NAYLOR

*Mr. Naylor is the founder of his company, the Maintenance Engineering Corp., also immediate past president of the Houston Chamber of Commerce and director of several companies including the M. K. & T. Railroad and the City National Bank of Houston.

Houston Section Welcomes National Officers

On June 19th the Houston Section was host to the National ISA Executive Committee at a banquet. President R. J. S. Pigott addressed his remarks to the members' wives and asked them to assist in making the 1951 National Instrument Conference and Exhibit in Houston a big success.

Secretary Richard Rimbach related some of his experiences during his recent trip to Europe.

This banquet was held in the Houston Club and preceded the Announcement Luncheon.

as its first president. He is now serving as chairman of the ISA Technical Committee on "Recommended Practices". He is chairman of the local committee for the ISA Conference and Exhibit to be held in September 1951 in Houston. It is now my pleasure to present to you, W. H. Fortney of the Humble Oil and Refining Company, Baytown, Texas.

Fortney, after acknowledging the men in the Houston Section who will be active in the Sixth National Instrument Conference and Exhibit, introduced "Reg" Pigott, in whose honor the luncheon was held.

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 921 Ridge Ave., Pittsburgh 12, Pa.

SENIOR ENGINEERS AND PHYSICISTS having outstanding academic background and experience in the fields of microwave techniques, moving target indication, servomechanisms, applied physics, gyroscopic equipment, optical equipment, computers, pulse techniques, radar, fire control, circuit analysis, autopilot design, applied mathematics, electronic subminiaturization, instrument design, automatic production equipment, test equipment, electronic design, flight test instrumentation, are offered excellent working conditions and opportunities for advancement in Aerophysics Laboratory of North American Aviation. Salaries are commensurate with ability, experience and background. Send information as to age, education, experience and work preference. Location California. Box 312.

INSTRUMENT ENGINEERS by large chemical manufacturer for work in various phases of Instrumentation including design, installation of control equipment for new and revamped facilities, general application, engineering and training of personnel. Must have degree and at least four or five years experience in industrial instrument field. Experience in chemical processing, petroleum, textile or instrument manufacturing industries preferred. Give background, experience and education in first letter. Age 24-40. Salary 450-600 per month. Immediate employment. Box 313.

INSTRUMENT SERVICE ENGINEER excellent opportunity for instrument mechanic with five years maintenance experience in electrical instruments, pneumatic controls, flow, temperature and pressure. Engineering degree desirable but not necessary. Must be ambitious to progress to full sales status at end of two years. Must pass aptitude tests for sales. Car required. Salary and expenses. Age not over 30. Location Pittsburgh, Pa. district office of major instrument company. Give complete resume of background in first letter. Box 314.

Section Secretaries, Meeting Data and Programs

AKRON
Fred Appel, 932 Columbia Ct., Barberton, Ohio. Tel: SH 3440
Fourth Tuesday, Meeting at 7:30 P. M., Akron Y.W.C.A.

ALBUQUERQUE
L. J. Paddison, 911 Parkland Circle, Albuquerque, N. M. Tel: 5-1806
First Monday, Meeting at 8:00 P.M., Science Lecture Hall, Univ. of N. M.

ARUBA
K. H. Walker, P. O. Box 389, c/o Lago Oil & Tranpsort Co., Ltd., Aruba, N.W.I.
First Tuesday, Meeting at 7:15 P. M.

ATLANTA
H. Kockritz, Fischer & Porter Co., 84 Peachtree St., Atlanta, Ga. Tel: CY 1269
Fourth Monday, Meeting at 7:45 P.M., Ga. Institute of Technology.

BALTIMORE
George B. Greer, 631 E. 36th St., Baltimore 18, Md. Tel: Chesapeake 6879
Second Friday, Meeting at 8:00 P.M., Engr's. Club of Baltimore.

BATON ROUGE
John Q. Bass, 1517 Longwood Dr., Baton Rouge, La. Tel: 3-0283
Meeting at 7:30 P.M., L.S.U. Physics Bldg.

PRECISION OPTICAL FOREMAN must be experienced in all phases of precision optical manufacturing, including grinding, polishing, contacting, blue print reading, testing, etc. By manufacturer of precision optical elements such as lenses, optical flats, prisms, parabolic mirrors, etc. Location Washington, D. C. Box 315.

INSTRUMENT MECHANICS responsible positions are open in the new field of nucleonics at Hanford Works, Richland, Washington. Hanford Works is operated by G. E. for the U. S. Atomic Energy Commission. Positions require maintenance, repair and calibration of a variety of complex industrial and electronic instruments. Those accepted will also assist on special instrument and control system work. Applicants must be citizens of the U. S. and have had a minimum of three years work in the instrument craft. Experience or training in electronics is desirable. Box 316.

MAINTENANCE AND REPAIR MECHANIC for instruments of Tagliabue, Foxboro, Cochrane flow meters, Niagara and Sparling water meters, Fisher controllers, Powers regulators and controllers, Leeds and Northrup. Steady day turn. Must have five years experience in chemical, petroleum or instrument manufacturing industries. Top rate. Excellent opportunity. Location Chicago, Ill. Box 317.

INSTRUMENT MECHANIC five years experience with pneumatic and mechanical process instruments, potentiometers, pyrometers, etc. Location Pittsburgh, Penna. vicinity. Box 318.

BOSTON
C. J. Nazzaro, 456 Central Avenue, Milton 87, Mass. Tel: CU 6-2479
Last Wednesday, Dinner at 6:30 P. M., Meeting at 7:00 P.M., Patten's Restaurant.

CALIFORNIA
D. C. Duncan, Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif. Tel: SY 4-8439
Second Wednesday, Dinner at 6:30 P. M. Meeting at 8:00 P. M.

CENTRAL ILLINOIS
H. F. Lange, 2101 W. Glen Avenue, Peoria 5, Ill. Tel: Peoria 5-4516
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
H. F. Coffey, 4029 N. Temple Ave., Indianapolis, Ind. Tel: HU 5832
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
Karl W. Robertson, Minneapolis-Honeywell Reg. Co., 121 W. Onondaga St., Syracuse, New York.

CHARLESTON
Clayton A. Williams, 303 E. 9th St., Belle, W. Va. Tel: 927871
First Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Kanawha Hotel.

CHICAGO
Floyd E. Ertsman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago, Ill. Tel: WE 9-0686
Third Tuesday, Dinner at 6:45 P. M., Meeting at 8:00 P.M., W.S.E. Auditorium.

CHINA LAKE
A. H. Staud, 1004 Michelson Lab., USNOTS, China Lake, Calif. Tel: 77882
Fourth Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS.

CINCINNATI
Edward H. Muhleisen, 320 Durrell Ave., Cincinnati 15, Ohio. Tel: PO 1168
First Monday, Meeting at 8:00 P.M., Eng'r. Society Hqs.

CLEVELAND
A. E. Ehrke, 1732 East 291st St., Wickliffe, Ohio.
Fourth Wednesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Cleveland Eng'r. Society.

COLUMBUS
W. C. Myers, c/o Battelle Memorial Institute, 505 King Ave., Columbus, Ohio. Tel: UN 3191, Ex. 248
Third Thursday, Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecilia St., Cumberland, Md. Tel: 583-W
Tuesday after Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Algonquin Hotel.

DETROIT
Seymour Sterling, 13331 Linwood, Detroit, Mich. Tel: Tyler 5-1707
Second Wednesday, Meeting at 8:00 P.M., Rackham Bldg.

EASTERN NEW YORK
W. R. McKegg, c/o Gen. Engrg. & Consulting Lab., G. E. Co., Schenectady, N. Y.
First Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M.

GULF COAST
W. N. Sloan, E. I. Du Pont de Nemours & Co., Orange, Texas. Tel: 8411 Ext. 444
Third Tuesday, Meeting at 7:30 P.M., Lamar College.

(*Continued on page* 721)

THE SECRETARY'S PAGE

Richard Rimbach

THE following information has been abstracted from the report made by the Executive Secretary to the Executive Committee at their meeting in Houston, Texas on June 19th, 1950, at the Rice Hotel.

Society Membership: The membership of the Society now numbers 4300. This is an increase of 76 members over the count made in January 1950. Below is a breakdown of the Society membership by Section affiliation and grade of membership. Two deaths among the membership have been reported to the National Office, that of Mr. Peter L. Sibley of 18 Wall St., Foxboro, Mass., member of the Boston Section; and Mr. E. J. Calnan of 208 Russell Ave., St. Catharines, Ontario, Canada, member of the Ontario Section.

Reproduced below is a table of membership growth by years.

New ISA Sections: Sections of the Society now number 52. Four new groups have been granted Charters since September 1949. These are:

	Chartered	Members
Wilmington	12- 2-49	77
Panhandle	2-10-50	43
Toledo	4-15-50	*
Central New York	5-15-50	20

*Expected: 83

Visits of Secretary to Local Sections: Since the September Annual Meeting the Secretary has attended the following Section Meetings:

Sept. 30, 1949 Northern California Section Executive Committee Meeting, San Francisco
Oct. 4, 1949 California Section Meeting, Los Angeles
Oct. 7, 1949 Organizational meeting at Denver
Oct. 8-11, 1949 Houston Section Executive Committee Meeting and calls pertaining to 1951 Meeting
Oct. 24, 1949 Pittsburgh ISA Regional Meeting
Nov. 28, 1949 New Jersey Section Meeting
Dec. 5, 1949 Syracuse organization meeting
Dec. 6, 1949 Niagara Frontier Executive Committee Meeting
Dec. 7, 1949 Wilmington Section organization meeting
Jan. 27-28, 1950 New York Section Regional Conference
Feb. 20-21, 1950 Buffalo Allocation Committee; Executive Committee and Joint Steering Committee Meetings
March 7, 1950 Chicago and Northern Indiana Sections Joint Meeting
May 23, 1950 Akron Section Meeting
May 24, 1950 Meeting with Finance Committee Chairman, New York

Sound Slide Film of St. Louis Exhibit: In response to two News Releases sent to ISA local Section Officers, two announcements in the Journal as well as listings in the Calendar of ISA Section Activities, many letters, and from publicity received elsewhere—the Sound Slide Film "A Tour of the Fourth National Instrument Conference and Exhibit," has been shown at ISA Section Meetings and to other groups as follows: Film No. 1: 11 Section Meetings and 8 other groups, Total—19; Film No. 2: 8 Section Meetings and 8 other groups, Total—16; Film No. 3: 4 Section Meetings and 8 other groups, Total—12; Total showings: 47.

All comments received from those who saw the films have been favorable. Groups other than ISA Sections who have seen the film include: The Mine Safety Appliances Co., The American Medical Association, Photoswitch Inc., Standard Oil Co., and General Mills Inc. News Releases will be sent out at the end of the Section year advising that the films are available for loan to any interested group.

Charges made on the exhibitors who participated in the film have liquidated the expenses incurred in its assembly and in addition have supported the purchase of a recorder, projector and amplifier necessary for showing the film.

Film on Control Principles by G. F. Akins and J. H. Kowalski: The photography and sound tract on this film is being edited and the sound is being matched to the picture. One or two scenes must be retaken. The film will be ready for its premier showing at the Buffalo Instrument Conference.

Buffalo Exhibit a Sell Out: The original 165 booths planned for the Buffalo Exhibit have been completely sold. This is the first time in its history that the Instrument Exhibit has been sold out before its opening date. To accommodate those companies who still wish to exhibit, 26 additional booths have been laid out. (Of these 26, 11 have been reserved to date).

Co-sponsoring Societies of the Conference and Exhibit are: The Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers; The American Institute of Physics; The Institute of Radio Engineers; The Instruments and Measurements Committee of The American Institute of Electrical Engineers; The National Telemetering Forum.

The ASME, the AIEE, the AIP, the National Telemetering Forum and the IRE will occupy booths at the Exhibit. In addition the U. S. Naval Ordnance Laboratory and the U. S. Navy Department, Office of Public Relations, will exhibit.

Tentative Recommended Practice, RP5: The distribution of copies of this Recommended Practice to the entire membership has begun. The distribution of Volume 3 of the ISA Proceedings was completed by February 15, 1950.

ISA MEMBERSHIP as of June 1, 1950

Section	M	AM*	SM**	Total
Akron	37			37
Albuquerque	41	18		59
Aruba	40			40
Atlanta	18	1		19
Baltimore	69	5	1	75
Baton Rouge	47			47
Boston	94			94
California	177			177
Central Illinois	33	2	1	36
Central Indiana	26	53	2	81
Central New York	18		2	20
Charleston	67	4		71
Chicago	236	22	77	335
China Lake	46			46
Cincinnati	61		2	63
Cleveland	127	5	4	136
Columbus	25	4		29
Cumberland	14	1		15
Detroit	62	2	2	66
Eastern New York	54	2	42	98
Gulf Coast	39	1	2	42
Houston	136	2	2	140
Kansas City	40	19		59
Louisville	30	2	2	34
Montreal	83		3	86
New Jersey	244		8	252
New Orleans	6		1	7
New York	180	13	30	223
Niagara Frontier	71	13	4	88
North Texas	24	1		25
Northern California	102			102
Northern Indiana	22	4	1	27
Oak Ridge	68		1	69
Ontario	40			40
Panhandle	43			43
Philadelphia	295	14	13	322
Pittsburgh	201	7	34	242
Presque Isle	18	1		19
Richland	58	11	10	79
Rochester	67		4	71
Sarnia	60	11	2	73
South Bend	2	2		4
South Michigan	16	8	3	27
South Texas	33	9	9	51
St. Louis	131	3	3	137
Tennessee	34	17		51
Tulsa	92	2	2	96
Twin Cities	23	16	2	41
Washington	60	56	1	117
Wayne County	54	21	2	77
Wilmington	72	4	1	77
At Large	30	4	1	35
	3666	358	274	4300

*Associate Members
**Student Members

MEMBERSHIP GROWTH BY YEARS

8/46	1075	
12/46	1650	23
4/47	2121	27
8/47	2296	32
3/48	2966	
8/48	3280	41
3/49	3762	44
5/49	3908	44
9/49	3880	47
1/50	4224	49
6/50	4300	52

Bruce A. Irwin

Bruce A. Irwin, who was very active in the early stages of the organization of the ISA was killed instantly in an automobile accident in Glastonbury, Connecticut, on June 15th.

Bruce was driving with his wife and one daughter to attend the graduation of his younger daughter at the University of Michigan where Bruce received his degree in 1923. His wife was seriously injured and his daughter had to be treated for bruises and shock.

He was employed for 15 years by the Mason-Neilan Regulator Company until his appointment in 1946 as sales manager of the Hammel-Dahl Company. Later he was appointed secretary, then vice president.

From 1942 to 1944 he was secretary to the Materials Coordinating Committee and Chief of the Materials Requirements Section of the Petroleum Administration for war.

this particular stage has a 45-degree mitted to the oscillograph and appear under extreme physical conditions

An FM/FM Telemetering System*

By W. J. MAYO-WELLS†

THE SYSTEM herein described employs a number of frequency modulated sub-carriers, or tones, which are used to modulate a frequency-modulated radio link transmitter. Such a system is designated as an FM/FM system of telemetering. It is shown in block diagram form in Fig. 1.

The first FM/FM telemeter was designed and built at Princeton University in 1943 under an N.D.R.C. contract. It used two sub-carriers and recorded continuously two channels of information. From this primitive unit a number of systems were developed, and were in active operation by 1945. As the demands for information increased, ways and means had to be found to accommodate them. This was accomplished partly by an increase in the number of sub-carriers, and partly by the use of commutation as explained later in this article. The commonest number of sub-carriers is at present six, but theoretical considerations have shown that fifteen is a practical figure, and, even this does not appear to be the limit. It may also be possible to include two or more radio links, in which case the number of channels visualised is very large indeed. The high percentage of successes under very extreme conditions, and it is safe to say that it has been the instrument for much significant research.

system under consideration has had a

Fig. 2 shows a block diagram of the converting equipment. It consists of the band pass filter, audio discriminator, d-c. amplifier and magnetic oscillograph. The band pass filter transmits only a narrow band of frequencies, plus or minus 7.5 percent around the chosen sub-carrier frequency, this being sufficient to record the limits of the changes in the physical quantity under measurement. The discriminator, which is of the pulse averaging type, converts the changing audio frequency into an amplitude modulated d-c. signal. The d-c. signal is amplified and fed to one circuit of a magnetic oscillograph from which a trace is obtained on the record which is shifted from a zero position, corresponding to the chosen sub-carrier frequency, as the audio frequency is varied by the changing physical quantity at the pickup.

A compact frequency modulated radio transmitter has been built to operate in the lowest of the FCC assigned telemetering bands. A reactance tube is modulated by the complex audio signal from a number of sub-carrier oscillators, and this in turn is used to frequency modulate an r-f. transmitter consisting of an oscillator, doubler and push-pull amplifier.

The remote receiver is of conventional design and converts the incoming r-f. signal into a Foster Seely discriminator, and supplies to the band pass filters the same complex audio frequency signal, as was used to modulate the transmitter installed in the test vehicle. Provision is also made for monitoring the strength of the received r-f. signal, and for extracting the complex audio signal before frequency limiting circuits when it is required to record intelligence with a very high frequency response requirement. After separating the super audio sub-carrier it is converted by a special discriminator and the d.c. fed to a camera-scope for recording.

The basic principle of the variable inductance is as follows: A coil is wound on an E shaped former which is made up of laminated stampings, great care being taken to see that the exposed surface is level and at right angles to the axis. With the E coil is associated a mu metal armature and by punching small holes in the diaphragm through which the oil is forced. The diaphragm has a balanced mass at the center. One half of the mass is made of mu metal and forms the armature. Under an accelerating force the diaphragm is distorted proportionally and, as in the case of the pressure gage, the inductance of the E coil is changed.

In the angular position pickups the distance between the mu metal pad and the E coil is set to give a chosen sub-carrier oscillator frequency, and to allow a very small change in this distance to shift that frequency over the full bandwidth of plus or minus 7.5 percent. The movement of the pad is effected by a screw, which in turn is operated by rotation of a pinion gear firmly secured to it. Another gear or a sector or a rachet may engage the pin-

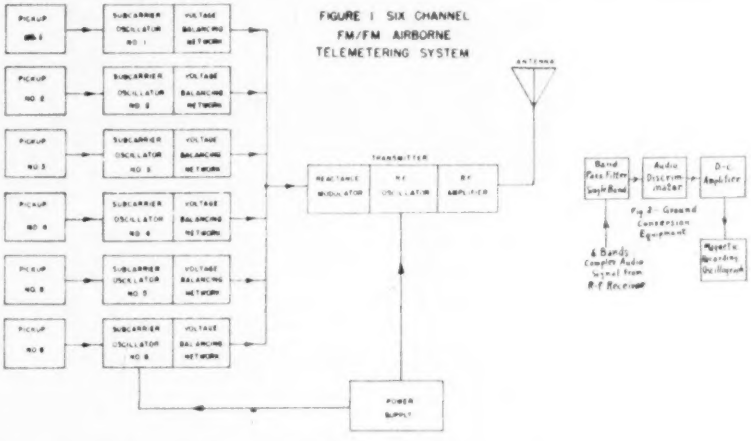


FIGURE 1 SIX CHANNEL FM/FM AIRBORNE TELEMETERING SYSTEM

Fig. 2—Ground Conversion Equipment

the relative distance between the two determines the value of the inductance forming part of a Hartley or Colpitts oscillator, Fig. 3. The nominal value is 130 millihenries, and variations of 15 per cent are obtained. The combined pick-up and oscillator convert variations in the physical quantity to variations in the frequency of an output voltage around the "zero" sub-carrier frequency.

Pressure pickups can be designed to operate over a wide range of pressures, and to measure absolute or differential pressures. The pickups or gages consist of a metal case in two parts. A beryllium copper diaphragm separates the two pressure compartments. On the diaphragm is mounted the armature facing the E coil. Changes in the pressure applied to one compartment, that in the other being held constant, distort the corrugations in the diaphragm, causing the gap between the armature and E coil to alter. For a differential measurement both compartments are connected to external pressure sources, and the armature movement depends on the difference between the two pressures.

A similar device is used to measure translational acceleration. Damping is effected by filling the unit with oil and ion, and the whole combination must be chosen so that the limiting positions of the sector, either side of the agreed zero, must result in a 7.5 percent change in the frequency either way. In cases where a two slope sensitivity is required the screw may be replaced by a cam, which allows almost any desired characteristic to be obtained. An ingenious method has been evolved for cutting these cams to remarkable accuracies using a standard angular position pickup and the frequency measuring gear to be described later. Once the master cam has been cut it is a simple matter to fashion duplicates at a fast rate.

Quite different principles must be employed to measure strains, temperatures, voltages, vibrations and liquid flow. Only voltage measurements will be described as applied in the instrumentation of high altitude rockets.

The circuit used to record the outputs of cosmic ray pulsescounters and other voltages is seen in Fig. 4. It incorporates a four stage phase-shift network with one of the resistor elements composed of the modulator cathode and a series resistance. Changes in the voltage applied to the modulator grid alter the effective value of the series combination and hence the frequency at which

Note:—Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

*Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 13-16, 1949, St. Louis, Mo.

†Applied Physics Lab., Johns Hopkins Univ., Silver Springs, Md.

this particular stage has a 45-degree phase shift. Since for the oscillation condition the total phase shift must be 180 degrees, if the circuit element is changed the only way for an oscillation to be maintained is for its frequency to shift until the 180-degree phase shift is restored. A cathode follower stage is interposed between the plate of the oscillator and the phase shift network to improve the stability.

Any of these individual units may be combined into a modulating system provided that there is no duplication of sub-carriers and all recorded continuously. Each of the units is made to plug into a standard strip which can be made in a number of lengths. The basic length allows for one inductance oscillator, the voltage oscillator occupies two lengths and other types of oscillator three. The strips can be made to accommodate any combination of these units.

Thus the distinctive feature of this system is the great flexibility of the building block construction. This flexibility ensures that only the most appropriate units need to be installed in any given vehicle affording maximum efficiency, a condition not always realizable with the large unit type of telemetering construction without extensive and wasteful modifications.

When it is required to increase the intelligence capacity still further commutation may be employed. This may be either input or output commutation. Input describes the periodic sampling of a number of pickup signals, as indicated for strain gage bridges, and the feeding of them in time sequence to one sub-carrier oscillator. This system is not yet available with inductance type pickups, but a new oscillator shows promise of accomplishing this difficult task. Output commutation describes the periodic sampling of a number of audio oscillator outputs, each operating in a common sub-carrier band and feeding them in time sequence to the transmitter.

The individual signals fed to the transmitter must be carefully adjusted in amplitude to prevent excessive deviation of the radio frequency, and this is now accomplished by built-in miniature potentiometers on each oscillator.

The over-all frequency response varies with each band, rising with a rise in the sub-carrier frequency. The speed of the switch operation must be such that a readable sample is recorded on the film after any switching transients have ended. The Miller oscillograph has been adopted to give the maximum frequency response on each intelligence channel. This means however that frequencies may also be transmitted to the oscillograph and appear as noise. It is therefore necessary to remove these unwanted signals with a very selective low pass filter, but when excited by a commutated pulse this type of circuit rings. This ringing transient appears at the beginning of each commutated sample, and its duration must be added to the length of the readable sample in determining the switching speed. The frequency response for a given band is obtained by assuming a deviation ratio of five and a bandwidth of plus or minus 7.5 percent, than for these conditions.

Permissible (f max) intelligence frequency=

$$\frac{\text{sub-carrier frequency} \times \text{b.w. percentage}}{\text{deviation ratio}}$$

For a sub-carrier of 4000 cps. f max. = 60 cps.

For a sub-carrier of 40000 cps. f max. = 600 cps.

For f max. = 600 if the ringing lasts 2 cycles and a readable sample lasts 2 cycles, the sample length must be 4/600, or 7 milliseconds, to reproduce it faithfully. Thus, if the switch rotates at 4 rps., and has 30 contacts in a cycle, it will make 120 contacts in a second, and the sample time per contact would be 8 milliseconds, which meets the requirements set up above. For 4 cps. response each input must be sampled 20 times in 4 revolutions or 5 times in 1 revolution. So six inputs can be commutated with 4 cps. response or twelve with 2 cps. or eighteen with 1 cps. response. Using these principles a great variety of switch speeds and input combinations can be accommodated to give a certain response frequency.

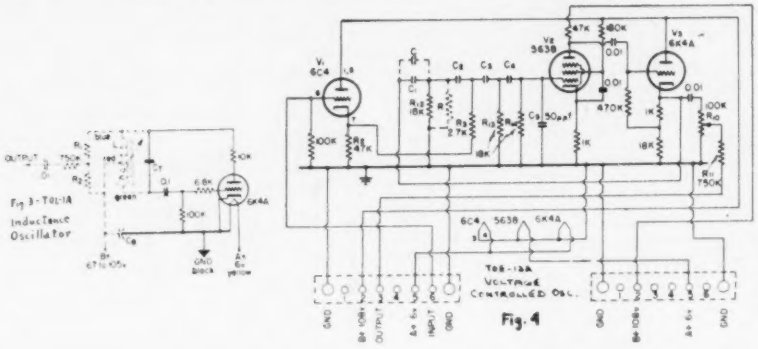


Fig. 4

Power supplies may have to be held to close tolerances to prevent instability in the "zero" frequency of an oscillator, and to preserve linearity. A small dynamotor, driven from batteries, has been found to be the most suitable power source. The output may be regulated by a miniature voltage regulator tube with series resistor. ER46 acid batteries serve best as filament supplies.

This telemetering system has been designed to occupy a minimum volume, and here again the building block construction allows the installation to be made in odd spaces, and to conform to many desired shapes. Where space permits as in a large rocket the entire assembly can be built up into a compact block utilizing a high space/weight ratio. Alternatively it can be widely dispersed, and, if care is taken in the type and method of wiring, no troubles should be experienced on account of long leads.

The units are designed to operate under extreme physical conditions to meet these conditions without detriment to their performance, and to give a satisfactory life consistent with their use. While the following type tests are still a goal rather than an actual achievement in many cases, they are presented as an indication of the possible standards of such a system.

Voltage stability: 1 percent b. w. shift for 10 percent change in B voltage and 20 percent change in A voltage. Some units may require regulation of B voltage with regulator tube.

Temperature: Suspension in atmosphere of 300 F. for 10 minutes. Operate after exposure to —50 F. for 1 hour and then warm up for 5 minutes.

Pressure: Minimum 7.5mm Hg at above temperatures.

Vibration: Plus or minus 15g in two directions at right angles.

The accuracy of the over-all system is difficult to determine in view of the large number of factors included in any such computation. An aim has been set at plus or minus 2 percent. This figure would be commensurate with similar measurements in the laboratory, and depends to some degree on the accuracy of the calibrating instruments. Reliability should be one hundred percent.

As a part of the development program a comprehensive scheme of technical literature has been evolved. Each unit has been fitted into a somewhat arbitrary nomenclature, such as TOL for a Telemetering Oscillator of the Inductance type, and Data Sheets are prepared when the unit is ready for production engineering. Production Specifications supply all the test information for manufacturers. Design Specifications cover basic general principles of the system, and Application Information Sheets complete the documentation available to all approved users.

It must be evident that such an intricate system of instruments as is included in a technical vehicle installation requires systematic testing and calibration. Wherever possible each pickup and oscillator is calibrated in the laboratory before installation, and a number of special equipments have been devised to facilitate this work. After installation, if at all practical, a number of spot checks should be made and compared with the calibration curve of the physical quantity v frequency. As a minimum the "zero" frequency must be checked. The measurement of frequency to an accuracy of one cps. in 5000 cps. is accomplished in the following manner. A tuning fork controls the frequency of a Hewlett-Packard audio oscillator whose output is fed to one side of a balanced modulator. The signal frequency to be measured is fed to the other side of the modulator, and the difference output applied to the vertical plates of a cathode-ray oscilloscope. A second oscillator is connected to the horizontal plates. When the frequency of this second "interpolation" oscillator is adjusted to give a Lissajous circle oscillogram on the oscilloscope the difference between the tuning fork frequency and the interpolation oscillator reading is the unknown frequency required.

In conclusion it may be said that this system of telemetering is convenient, adaptable, and reliable, and should find ready application wherever a remote indication or record of the changing physical quantities in a moving test vehicle is necessary.

The Effect Of Control Point Location Upon Column Control*

By K. D. UITTI†

IN THE design and instrumentation of a large number of precise fractionators for the war program, many and lengthy discussions were held by private groups on the matter of the proper primary control instruments to be used on columns and, if temperature control were used, where in the column would be the proper control point location. As process engineers, we naturally were not as much concerned with the specific kind of instruments that should be used with respect to range, sensitivity, or response, but with the basic way in which a column should be controlled from a process-cybernetic viewpoint. This is in fact the subject matter treated in this article.

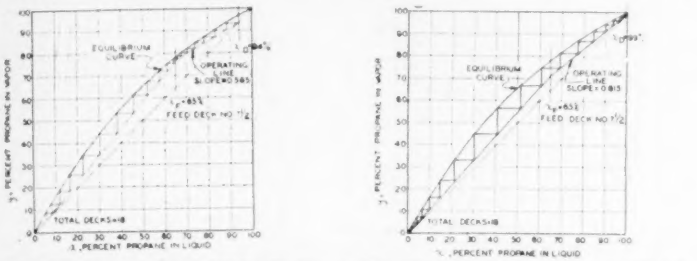


Fig. 1A (left) Typical McCabe-Thiele diagram for the system: propane-isobutane at 200 psig. when fractioning to 94 percent distillate. Fig. 1B (right) Fractionation to 99 percent distillate with the same column and feed deck location.

The published literature reveals numerous generally accepted statements that have been made and which could be proved or disproved merely by calculation. It occurred to us that perhaps too many assertions were made that were either dogmatic or gave the superficial appearance of common sense. Perhaps in the interest of objectivity, we should examine these tenets to see whether they withstand the rigors of physical and mathematical proof. In about 1942, J. R. Penisten** conceived some ideas of the manner in which some of the questions might be tested by calculation. There is no doubt today that the methods generally used in calculating the fractionation are essentially correct. There is certainly sufficient proof that these methods can be used to predict with fair precision the actual performance in fractionators.

The series of calculations presented here continues the work suggested by Penisten along these lines. The system selected was the binary: propane-isobutane at a constant pressure of 200 pounds. In order to properly duplicate those conditions which do confront instrument engineers, the total number of decks and the feed deck location were held constant throughout all cases. For design purposes, these several conditions constitute what we have termed a "fixed column." These studies were thereby reduced to a matter of making numerous McCabe-Thiele calculations in such a way that the feed deck location and the total number of decks for each case came out the same. A series of approximations for each "test" was necessary. Fig. 1 illustrates a typical set of McCabe-Thiele graphical calculations where the feed deck location and the total number of decks are constant at the same feed composition, x_f, but at different reflux ratios, indicated by the different slopes of the operating lines, an arbitrary selection of a fixed column of 18 decks with the feed deck being located 7-½ decks from the top. These values refer to theoretical decks, that is, decks which bring the liquid and vapor into perfect equilibrium.

Series I. Deck Temperature Curves

The object of this series of tests was to determine whether there is any deck in the column where the temperature changes more than that on any other deck for a given change in product composition. This series was performed on a feed of constant composition in a fixed column, and the reflux ratio was varied in order to achieve different product compositions.

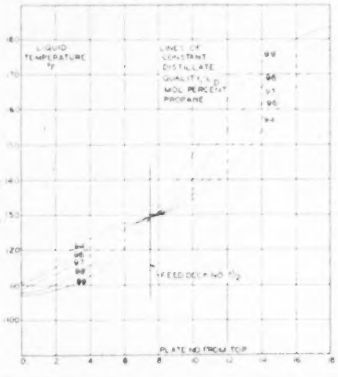


Fig. 2. Plate-temperature curves for the system: Propane-isobutane at 200 psig. when fractionation in a fixed column with feed composition x_F equals 65 percent propane.

Fig. 2 shows the deck-temperature curves for this system. The temperatures were read off a composition-temperature curve prepared for this binary at compositions corresponding to those found off the McCabe-Thiele diagrams. Note that there seems to be no particularly "typical" shape of plate-temperature curves, even for this binary of constant feed composition. Fig. 3 shows the amount that the temperature has changed. $\triangle T$, on any deck when the product quality has changed. For a datum plane of reference, these temperature differences, $\triangle T$, are compared to those deck temperatures which would obtain for a distillate purity of 99 percent propane. It is apparent from Fig. 3 that there is some deck which changes more in temperature than any other deck, and that this "maximum $\triangle T$-deck" is somewhere in the middle of each section of the column.

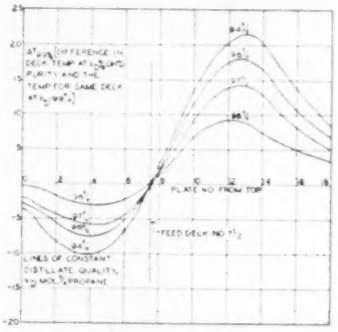


Fig. 3. Change of a given deck temperature with overhead composition for C_3/iC_4 at 200 psig. 65 percent C_3 in feed variable reflux ratio.

It must be emphasized that this conclusion may be true for any binary system whose McCabe-Thiele x-y diagram is symmetrical, but that great care must be exercised in making any such conclusion for a multicomponent system or for a binary which has an abnormal x-y diagram. An abnormal diagram is, by the way, one in which the relative volatility of the cut components varies considerably throughout the range of tower conditions from top to bottom.

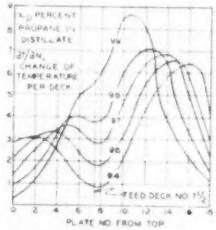


Fig. 4. Derivative curves. Differences of temperature between successive decks for fixed column with 65 percent propane in feed.

It is often stated that the control point should be located at that deck where a maximum slope occurs in the deck-temperature curve. Fig. 4 shows a derivative curve of Fig. 2 where the temperature differences between successive decks are plotted against deck number. This curve indicates that the inflection does not remain fixed in the column, but wanders according to the

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* Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 12-16, 1949, St. Louis, Mo.

† Universal Oil Products Co., Chicago, Ill.

** Now with Frontier Refining Co., Cheyenne, Wyoming.

reflux ratio. Reconsideration in view of these calculations shows that there is in fact no apparent justification for this plausible sounding method of control point location.

Series II. Constant Temperature On Maximum △ T-Deck

The previous Series I was made at constant feed composition. Since one of the purposes of instrumentation of a column is to provide for changes in the tower when the feed composition changes, Series II was performed to determine how well the distillate quality would remain unaffected by changing the feed composition when the temperature is held constant on the deck which was previously found to have a maximum △ T with change in reflux. In this case (Fig. 3) the fourth deck in the top section was used. The calculations were made on the same binary and for the same 18-deck fixed column. McCabe-Thiele diagrams were made for a group of different feedstock compositions in such a manner that the fourth (control) deck temperature was always at 118 F. and that there would be 18 decks in each test, set up in such a manner that the feed would be on deck No. 7-½. Again each test required a series of trials and crossplots.

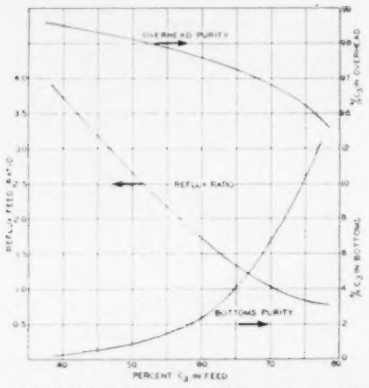

Fig. 5. Effect of maintaining constant temperature on fourth deck for C_3/iC_4 at 200 psig. variable feed composition, variable reflux ratio.

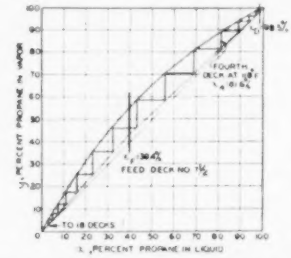

Fig. 6. McCabe-Thiele diagram showing maximum distillate quality possible in fixed column with fourth deck temperature maintained constant.

The results of this series may be seen in Fig. 5, which shows that the overhead product purity can be held quite constant when the feed composition is changed over an extremely wide range, but at the expense and nuisance value of a large variation in reflux rate. The control deck temperature in this case could be visualized in an instrumentation wherein the temperature controls the reflux rate and the reboiler is held at a constant heat input rate. When the feed becomes lighter, the reflux rate decreases in such a manner that the total overhead vapor decreases. Since there is a constant heat input into the reboiler, the heat balance is made up by increasing bottom temperature, with consequent purer bottoms product and less pure overhead product. If constant bottom product quality is desired, this method of control appears to have limited value.

Although we have not considered multi-component columns in detail, it is true that this method of control has one advantage in that small and variable amounts of components in the feed which are lighter than the light cut component will be at a minimum concentration at the control deck. Top temperature control in this kind of case would be disastrous.

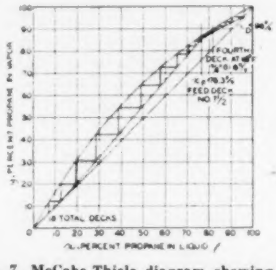

Fig. 7. McCabe-Thiele diagram showing minimum distillate quality possible in fixed column with fourth deck temperature maintained constant.

In this series, the control deck was held rigidly at 118 F. and the reflux rate was varied to fit the conditions stipulated for this particular fixed column. The control temperature of 118 F. corresponds to only one composition of a boiling binary liquid, viz., about 81.6 percent propane, which is the composition of the control deck in all of these tests. It is interesting to note that the product purity varies between two fixed limits of composition when the control deck temperature is held rigidly constant and the feed composition varies.

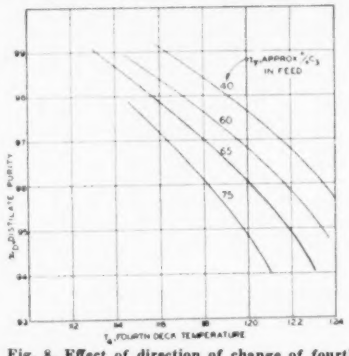

Fig. 8. Effect of direction of change of fourth deck temperature on distillate quality for C_3/iC_4 at 200 psig. variable reflux ratios and feed composition.

In this case the limiting compositions are about 96 and 98.5 percent propane, and no values outside of these limits are possible. Figures 6 and 7 show the conditions which obtain at these limiting compositions of distillate. The detailed McCabe-Thiele calculations show that when the feed decreases to a value of about 39.4 percent propane, (Fig. 6) the reflux ratio will increase up to an internal $L/V = 1.0$ as a limit, corresponding to a reflux rate of infinity. This condition will take place when the feed composition is so low that the operating line approaches the 45 degree diagonal in regions near the control deck. At this condition quite wide variations in feed composition will do very little to the composition (and hence temperature) on the control deck. Conversely put, when counting four steps upward from the control deck in this condition, a composition of essentially constant value of 98.5 percent will always be reached at the top deck, which represents the maximum of product purity.

Likewise, it can be shown conclusively that the minimum distillate purity attainable will be around 96 percent propane by reference to Fig. 7. If the feed composition is increased to such a point that when the 3-½ steps required to

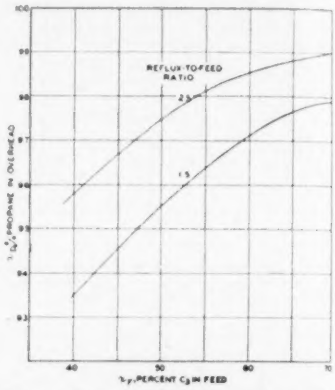

Fig. 9. Effect of maintaining constant reflux-to-feed ratio for C_3/iC_4 at 200 psig. using fixed column for variable feed composition.

reach the feed deck downward from the control deck (of fixed composition) are sketched in along such a line that the feed deck occurs at our fixed value of 7-½ steps from the top, the operating line will finally assume such a slope that the feed composition will have coordinates near the equilibrium line. This is the well known pinch region where small changes of composition are achieved per deck. The operating line then intersects at a minimum distillate composition value of 96 percent propane, below which value no product purities are possible. This control gives us a sort of guaranteed minimum quality of distillate. Upon inspection of Fig. 6 and 7, it will be seen that the operating line pivots about the control deck composition whose value here is fixed at 81.6 percent propane, corresponding to our previous arbitrary selection of 118 F.

One very important point to be observed is that the distillate becomes lower in propane content as the feed becomes richer in propane, a conclusion quite the reverse of "common sense" dictum, and one which would not be readily deduced without this type of thought.

It cannot be made a rule, from this, that all columns should have intermediate deck "maximum △ T-deck" temperature control, and achieve successful operation. For one thing, for wide feed composition fluctuation, there is enough change in reflux rate, perhaps, to flood a column, as can be seen from Fig. 5. Feed enthalpy is another consideration which has not been taken in-

to account, although its effect is not great in columns where reasonably high reflux ratios are necessary. The effect of holding the same control deck at other constant temperatures than 118 F. was determined; the results are given in Fig. 8, which shows the direction of change, although these absolute values of the ordinates are not reliable. Nothing particularly novel was found, and the direction of change confirms the result that would have been expected by superficial inspection. Increasing the control deck temperature lowers the distillate quality.

Series III. Constant Reflux Rate

For a column of constant feed rate but of variable composition, if the reflux rate is fixed at a given quantity of reflux per hour, the reflux ratio based on the distillate is variable. There are good reasons to suppose that a constant *reflux-to-feed ratio* is the important criterion rather than the customary textbook expression of reflux-to-distillate ratio, when a fixed column has a variable feed composition. A depropanizer which removes propane from a feed containing 1 percent propane will require a reflux-to-distillate ratio of roughly 150:1, but the same tower taking out propane from a feed which is half propane will require a reflux-to-distillate ratio of only roughly 3:1. This reflux-to-distillate ratio variation seems tremendous, but if translated to *reflux-to-feed* ratios, becomes a nearly constant value of 1-½:1.

A rough sort of mathematical proof will show that for fixed columns making the same purity of products at variable feed composition, the reflux-to-feed ratio can be considered constant, particularly if the feed composition changes are not great, as is nearly always the case.

An inspection of a series of McCabe-Thiele plots of various feed compositions, x_F, making the same distillate composition, x_D, will show that as the feed becomes lighter, the reflux-to-distillate ratio, R/D, becomes less. A plot of this reflux ratio R/D against the feed composition, x_F, shows a curve approximating the form of an equilateral hyperbola, or of the form

$$x_F \; R/D = C \qquad \text{(a constant)}$$

Since these fractionations under consideration are always essentially complete separations, x_F, the per cent of the light material in the feed, is essentially equal to the percentage of material taken overhead, or for a feed rate, F, and a distillate rate, D,

$$x_F = D/F$$

combining the foregoing equations,

$$(R/D)\;(D/F) = C$$

which reduces to

$$R/F = C$$

This equation shows that the reflux-to-feed ratio should not vary appreciably with varying feed composition, but that reflux-to-distillate ratio does to a very large degree. Unfortunately, the latter method of expressing reflux ratios is more prominently used.

This series of tests was to determine just how much the distillate composition would vary if no temperature controllers were used in the top section, but if the reflux-to-feed ratio were fixed. Corrections were made in the calculations for the small errors used in the assumption of the above derivation to make the calculations rigorous. The same fixed column of 18 decks with feed on No. 7-½ was used. The instrumentation visualized on this column is a reflux-to-feed ratio controller (or a reflux rate flow controller) on the reboiler operating the heat input. This temperature controller could also be located part way up the column. Although not shown on Fig. 9, the bottom product composition does not vary as much as it does in the previous case (see Fig. 5). The variation was between 0.9 and 4.0 percent propane in the bottoms over the range shown in Fig. 9.

The results from the trial-and-error calculations are presented in Fig. 9. This plot shows that a fairly reasonable control is possible by this method, not so good, perhaps as by the control of an intermediate deck temperature, but having the decided advantage of constant liquid and vapor traffic in the column, attendant with the benefit of constant process lag owing to holdup. A reasonable variation in feed composition would perhaps be one with a propane content fluctuation of 5 percent either way. In the constant reflux ratio method of control in this case, the distillate composition varied about 1.5 percent, whereas in the constant control deck temperature method, the distillate varied in composition by about 0.8 percent at around 50 percent propane in the feed. The reflux rate changed by a factor of 1.48 over the ± 5 percent variation in feed in the latter method.

All of these cases were studied on feeds at their boiling points. Similar studies on the effect of feed enthalpy should be made before conclusions can be drawn from these studies if applied to columns of quite different feed conditions. Multicomponent systems can be readily adapted to simple McCabe-Thiele work if the method of R. B. Smith and T. Dresser described in *Chemical Engineering Progress*, Vol. 44, page 789, October, 1948, is used.

Continued from page 715

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First Tuesday, Meeting at 7:30 P.M., Univ. of Kansas City.

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Fourth Tuesday, Meeting at 8:00 P.M., Seagram Auditorium.

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S. J. Mizuhara, 1075 Allard, Verdun, Quebec, Canada. Tel: TR 3252
Last Monday, Meeting at 8:00 P.M. Mechanics' Institute.

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First Tuesday, Dinner at 6:00 P. M. Meeting at 8:00 P.M., Essex House.

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W. H. Haney, 2927 Music Avenue, New Orleans, La.
No Regular Date, Meeting at 8:00 P.M.

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F. B. Leslie, 8856 Commonwealth Blvd., Bellerose 6, N. Y.
Last Monday, Meeting at 7:30 P.M., Statler Hotel.

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Instrumentation *in* Rubber Processing

By R. J. BROWN, Engineering Laboratory, Firestone Tire and Rubber Co. of California

WHEN asked by Mr. Adams of your Program Committee to present this subject, it was difficult to decide how to cover the ground. After some study I decided that it should be presented by telling of the different types of instruments and their application and use in rubber processing. I will try to cover as many of the instruments and types as time will allow.

First, let us consider weighing in the rubber industry. We receive many different products shipped to us by various manufacturers. These products are weighed when received, either by platform scales within the plant, or, on large forty-foot truck scales in the yard. These scales are fairly sturdy and the installation and maintenance would not be too expensive if due caution is used when loading and unloading the platform. The use of lift tractors has increased the maintenance on these platform scales because of two factors: First, they will not slow down when running the load of 5 or 6 thousand pounds on the scale. This causes a platform shift and pivot damage. Second, they pick up the load or drop it on the scales too fast causing damage to the pivots and head mechanism. To help prevent some of this damage we have installed rails which only let the truck go onto the platform in one direction and they have to take it off the same direction. This has helped to reduce some of the maintenance.

Having received the material, it next is weighed into batches which we call "compounding". This is done on small platform scales for the pigments which are solid. Scoop type scales are used for dusts and fine pigments.

In weighing, the same amount of any one pigment is used several times. It has been found that using predetermined type scales, with only "over" and "under" on the scales, gives more accurate weight.

*Presented at the 22nd Annual Meeting and Instrument Exposition of the Southern California Meter Association, Municipal Auditorium, Long Beach, Calif., Oct. 4, 5, 6, 1949.

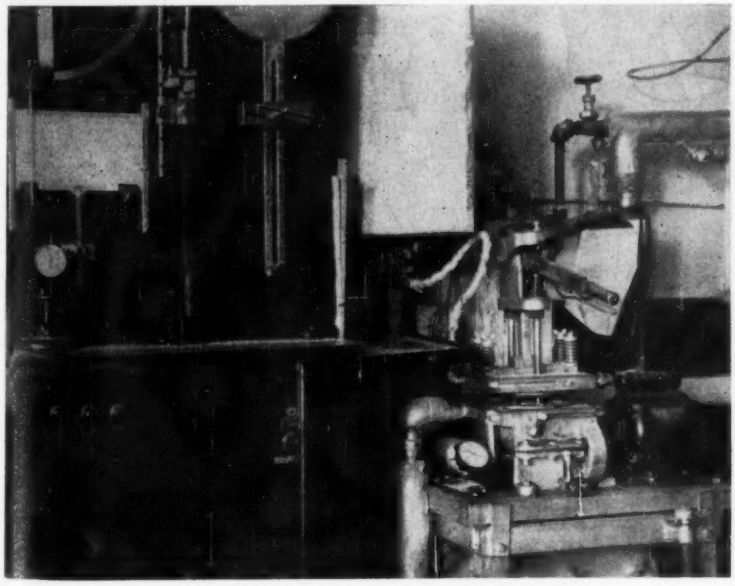
August Meeting: Thursday the 17th, 1950, Rio Hondo Country Club, Downey, Calif.

Features: (1) Julian A. Campbell of J. A. Campbell Co., will speak on the "Mist-D-Fier," the jet rivet absorber and the pulsation dampener, which his company has developed. Working models will accompany his talk.

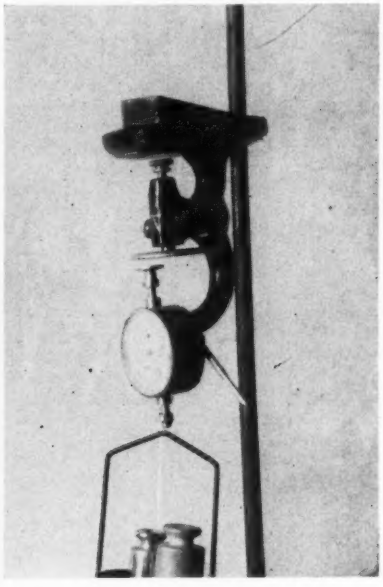
(2) Melroy Welch of Barnsdall Oil Co. will present "Maintenance of Mercury Type Orifice Meters," review from Meter Course brought up to date.

After several pigments are weighed into a batch, the batch bucket is checkweighed on a track scale with an automatic printer to print weight on batch cards. An addition has been made on this scale to automatically lock same, and an air cylinder has been added with a foot valve to unlock it. This method has reduced maintenance as it is almost positive to be left unlocked if the operator is depended upon.

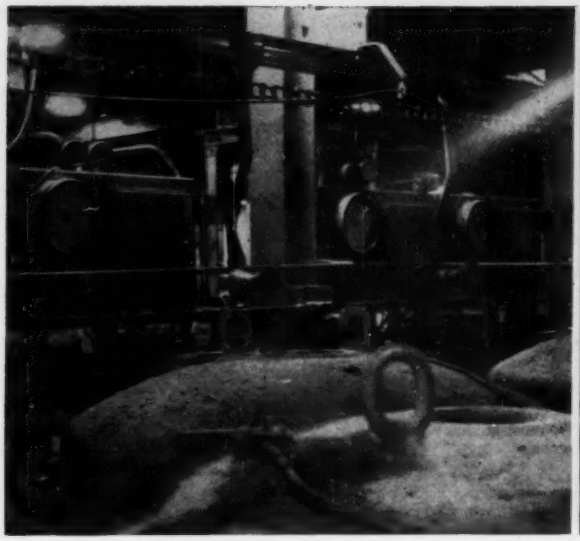
In some batches a large amount of carbon black is used. This is handled through a closed conveyor system and automatically weighed at each banbury. That is, the scales are set at a certain



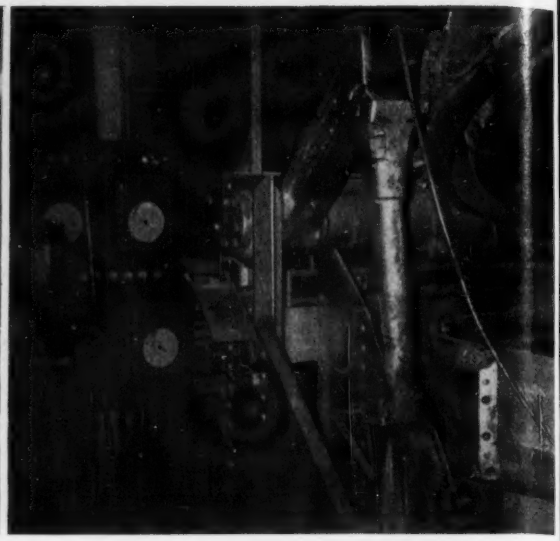
Mooney Plastometer, Ring Modulus



Thickness Gage Calibration



No. 1 BJM Temperature-pressure cycle control.



No. 4 BJM temperature-pressure cycle control

weight and then the conveyor is started. As the scale comes close to the correct weight, the conveyor is automatically slowed down and then stopped at the correct weight. This is accomplished by the use of a photoelectric attachment on the scales and a series of relays to operate the conveyor motors.

The next weighing is done after the stock leaves the tubers. There the stock is extruded in different shapes and it is necessary to keep the weight correct. This is done on a continuous-type belt scale of so many ounces per foot. This gives the operator an immediate check to keep weights right. This is necessary as the stock goes through a long cooling conveyor before again being cut to length and check-weighed by roller conveyor scales. To facilitate the speed and correct weights, the roller conveyor scales are predetermined-weight scales equipped with a photoelectric device which can be adjusted for various limits and shows different colored lights for over, under and correct weights within tolerance as previously determined.

Some of the stock is calendered into fabric and as this is done the weight of the stock is necessarily held to a certain amount. This is done by a weight Veriagraph which, by electrical capacity measurement of mass, is used to give the weight figures as determined by our laboratory on each side of a 60-inch width of fabric, thereby helping the calender operator to set the calender and obtain fabric of a given weight. This is a continuous operation and does not have to be stopped to obtain readings. The speed of operation varies up to 60 yards per minute.

There are other check scales used throughout the plant for spot checking and weights of parts of tires. The laboratory uses balances of the torsion and laboratory types to weigh samples and pellet batches. And, of course, the final product is weighed as it leaves the plant. You can easily see where weighing is an important part of the rubber processing.

Another important item in processing is the thickness of rubber stock when calendered on cord fabric. At the present, owing to cost and uncertainty of automatic devices, it is mostly done by the use of special thickness gages of the stand type. These gages measure up to a half-inch in thickness by 1/1000 of an inch. They are special in that, as rubber is compressible, the foot pressure must be maintained at a given standard. By changing the spring return and weighing the actual pressure developed by the gage, a pressure standard of 0.044 pounds per square inch is maintained in these gages. The foot area is three-quarters of an inch in diameter circle and this is a standard throughout the plant.

The troubles experienced with these are due to the operators. The operators seem to think that they should snap the gage to get the correct readings and this causes the movements to accelerate and decelerate at a very rapid rate, causing wear and pivot breaking.

We also get a lot of "help" from the operators who try to oil these gages, thereby making them operate sluggishly. These gages are calibrated to foot pressure and actual movement by using a table micrometer and standard weights which are attached to the spindle of the inverted gage.

Counters of different types are used throughout the plant, mostly to measure yardage. In some places the stock runs through a machine very fast and when it breaks the counter continues to spin. This gives false readings. To overcome this on certain machines we have installed special "spin-proof counters" which are counters with measuring wheels that have oil in them and brake paddles to stop them. However, at normal speed they take little more power to run than an ordinary counter. Special application of a yardage counter was made where the yardage on one end of the machine was recorded for the operator 50 feet away. For this a speed reducer 3-to-1 was used and a micro switch made contact every three revolutions of the 1-foot circumference wheel. The impulse then was recorded on an electric counter. Production counters are used of the photo-electric type and are standard in application.

Temperature control of steam for curing is accomplished several ways. On curing molds we have a rather long time lag of temperature from the steam capacity to the curing surface. This makes it rather easy to control and gives us the possibilty of using off-on control which is less complicated and has less diaphragm trouble.

Another good feature of off-on control is that it tends to purge the system of condensate and helps keep the system dry. Some control systems on series of molds have special circulation. Here again the pulsating type control helps keep the condensate carried out and gives more even temperature throughout the curing surfaces. Other systems have a steam circulating pump to maintain a constant differential between supply and return. This differential is controlled by the use of a by-pass and flow controller while the temperature is controlled by temperature control.

Several low-temperature control problems are handled by using a controller and valve positioners on water and steam mixers. A circulating system is used and the make-up is wasted. This has been especially good for tuber head temperature control.

Time cycle controllers are used in many places in the rubber industry. All cures are set up for a certain length of time at one or more temperatures and the amount of cure depends upon the time-temperature cure area.

In the early 1920's there were not very many of these devices used or made, so we built our own control. In

the design of this control we tend to incorporate a quick, positive method of changing time and temperature and, because we used a quick raise, we had to get an almost immediate change in temperature rise. To accomplish the first temperature of above, we made cams with holes in them at 5-minute intervals and the control arm ran on the circumference, thereby making the changing of time in 5-minute steps very quick and positive.

To get temperature rise very rapidly, the control arm was made to drop, to raise temperature. By this method, time intervals of two or three seconds were easily obtained to get a rise of about 250 F. if necessary.

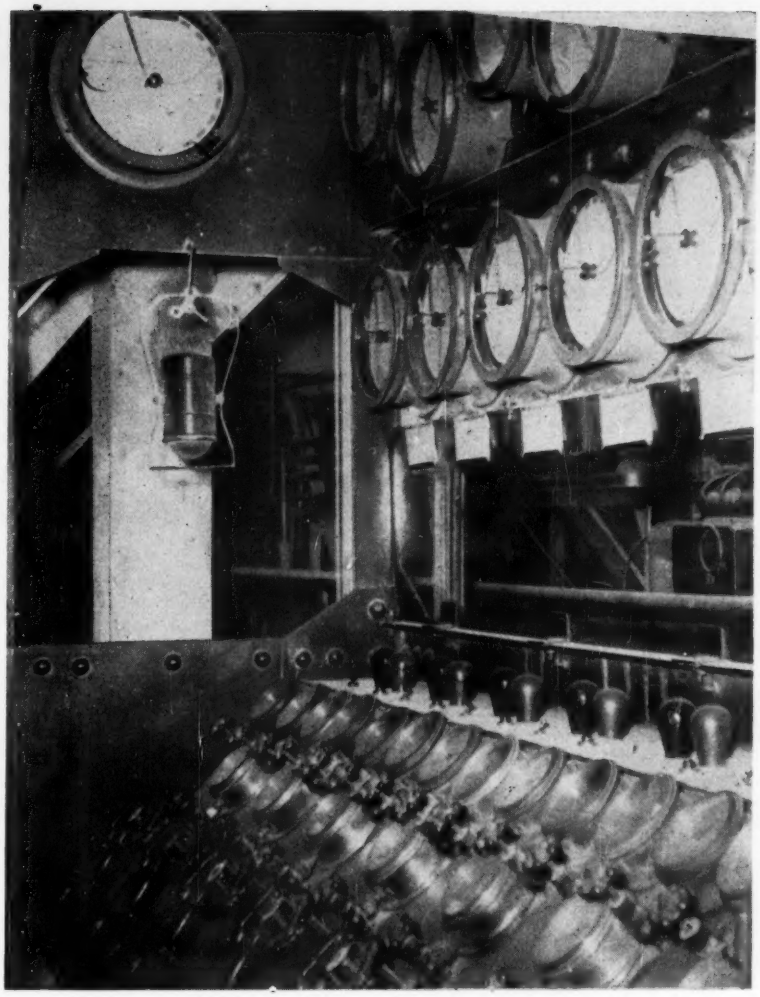
For control of the temperature, the cams were cut to a certain diameter and stamped so that the instrument man could quickly set up any cure.

At the end of the cure the shut-off was accomplished by a second lever which dropped and shut off the electric current to the drive motor and also applied air to the diaphragm valve shutting off the steam.

When starting control, a push button operated an electric air valve on the controller and, by means of air pressure on a cylinder, rotated the cams into starting position. Signal lights were also incorporated to show the controller operating or not operating and these were run into the control booth for the operator's convenience.

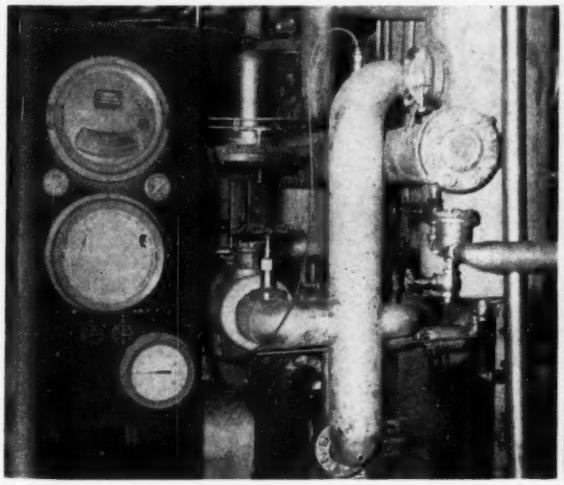
Cycle control of our individual curing stands is handled by conventional time cycle control where a timing motor drives a cam which operates pilot valves for diaphragm operation of different curing operations and services. Originally we had designed our own impulse and sequence controllers for this service before they were available from instrument companies, but at the present all new installation have instrument manufacturers' timers.

Our laboratory has many different instruments for physical checking and failure testing of compounds. Only a few can be mentioned:

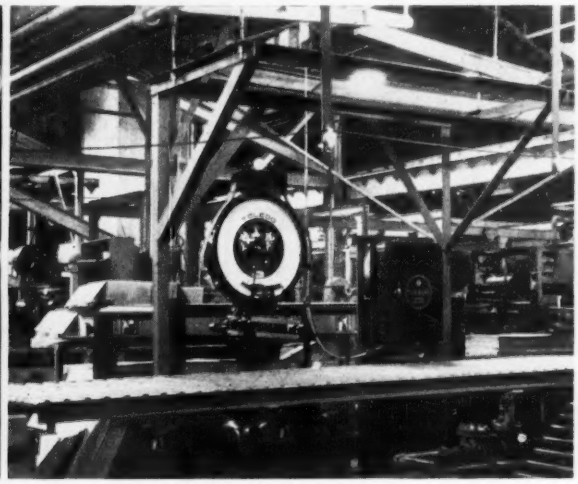


Heater Control Booth

The Dillon Extrusion Plastometer checks the plasticity of the rubber. The method is to warm the stock and extrude it through a given orifice at a given pressure and measure the time of displacement. The machine is aumatic; the operator starts the machine after a preheated sample is inserted;



Temperature and Differential Control on Steam System.



Tread Tubing Final Weight Scales.

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the temperature-controlled plates finish warming and shaping it; and then controlled air is applied on the piston. The travel is timed; the time is read by the operator and the counter is reset.

The Flexometer is another machine which actually flexes the compounded and cured rubber and the temperature rise is taken by inserting a temperature-controlled needle into the sample. This machine can run to destruction of the sample.

Temperatures of stocks in process are taken by the use of potentiometers with thermocouples extending into the stocks. Special installation and design are needed to prevent breakage and consequent contamination of stock.

In taking the temperature of the tire curing vessels called heaters, it was necessary to take the steam out of the vessel and run it up to a catwalk so as to install the heaters in batteries and to get the control so one operator could handle a number of heaters. In order to get a temperature to show on the loop, the same as was in the heater, a vent was designed and the steam wasted. The design of this vent to obtain correct temperature is very important!

In order to make a control booth for heater operation it was necessary to open and close large control valves from a remote point. This was accomplished by a small multi-port rotating valve designed and operates on 30-lb. air. To change this 30-psi. impulse to 300-psi. hydraulic water to operate the 6-inch valves, we designed an air-hydraulic relay valve using a D-slide valve with Stellite-seat spring return. The design of these valves took into consideration the maintenance and they are made to be changed without removing any pipe connections.

Diaphragm valves used in the industry are mostly conventional except in our factory where a quick raise in temperature is used. We have designed a multiple-diaphragm valve for this service; the valve body is 3-inch Series 300 and inside of the stem and seat assembly a secondary valve is used to give us a ¾ inch control valve after temperature is reached. The 3-inch valve closes on 3 to 7 pounds air pressure and the ¾-inch then operates on 7 to 15 pounds air pressure. When used in connection with an off-on control, the 3-inch valve does not open after about the first 3 minutes of cure, except where raises are necessary. Also part of the design of this valve is the ease of getting to the packing and also to the valve seats for repair and overhaul.

On some pigments it is necessary to measure the amount delivered. This is done by displacement meters and by weighing the pigments delivered.

All cost accounting through the plant requires that the steam, air and water lines be measured for monthly consumption. For this purpose we use standard flow meters with flat-plate orifice and integration. A daily record is kept and monthly report made. In the power plant all boilers are equipped with flow meters on the steam and water level. Our 700-pound steam boiler is also equipped with automatic combustion control. And there is a cycle control with a back pressure section between the turbines to give cycle control and use the extra exhaust steam from one turbine in the other and still maintain control of both cycle and pressure to process from this exhaust.

The Penetrometer is another instrument used for checking the cure on tires. It is made so that a round-nosed pin of definite diameter is pressed into the rubber with a definite load and the penetration noted in thousandths of an inch, thereby giving a definite indication of cure of the compound.

In closing I would like to say that there is still room for improvement in many of the instruments to adapt their use by the rubber industry. There are also a lot of instruments still to be developed and produced at reasonable cost to facilitate the taking of thickness and temperatures of the rubber compounds and the temperature of metal rolls without touching the stock or rolls.

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You need Taylor's New TRANSET* RECORDER

* Trade-Mark

MOVING THIS LEVER FROM NORMAL "SET" POSITION TO "VALVE" CAUSES SET-POINTER (extreme right center) TO INDICATE CONTROL VALVE OPENING.
AUTOMATIC-TO-MANUAL UNIT
STREAMLINED CLEAR PLASTIC DOOR ENCLOSES ALL ADJUSTMENTS, YET GIVES FULL VISIBILITY OF CHART, SET-POINTER, AND WHETHER ON AUTOMATIC OR MANUAL CONTROL.
SMALL IN SIZE 4¾"x5"
THREE HOURS OF CONTINUOUS RECORD, FULLY VISIBLE ON RECTILINEAR CHART
SET-POINT ADJUSTMENT
PROCESS CONTROL POINTER (left) DIRECTLY CONNECTED TO PEN, GIVES INSTANT COMPARISON WITH SET-POINTER (right).

This compact recording receiver for Pneumatic Transmission gives you:

1. AUTOMATIC-MANUAL UNIT
2. REMOTE SET-POINT ADJUSTMENT
3. VALVE POSITION INDICATION

Why You Need It. Conventional sized receivers caused oversized, complicated control rooms when the demand for central control with pneumatic transmission quickly grew. Compact graphic panels are the answer—*but*—Taylor's new TRANSET Recorder will simplify and eliminate conventional receiver wings on the most up-to-date panels. It indicates *and records* in the space usually needed for indicators alone. (Panel space—$4\frac{3}{8}$" x 5"). For Flow, Liquid Level, Pressure and Temperature—for graphic or conventional panels.

It gives a continuous 30-day process record with three hours visible—remote setting of control point—automatic-to-manual unit—instant check on controller performance—and control valve position—*all these*—right where you want them!

Here Are A Few Unique Advantages:

1. ***Easily removable chart-drive mechanism for re-loading.***
2. ***Scale shows actual transmitter process range—is graduated 3-15 psi. for checking calibration and valve position.***
3. ***Automatic-to-manual feature gives easy start-up—makes it easy to service controllers.***

You Can Get These Four Models: (**1**) One process record, set-point indication, set-point adjustment, valve position indication, and automatic-to-manual unit. (**2**) One process record, valve position indication, and remote manual valve loading. (**3**) One process record only. (**4**) TRANSET Indicator—operation same as Recorder only with indication instead of 30-day chart record. **Send for Bulletin 98079.**

Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

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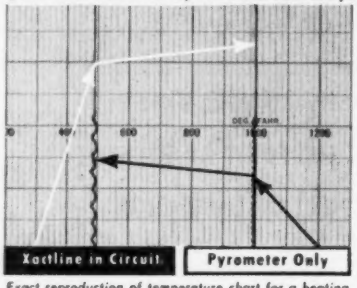
IN HOME AND INDUSTRY

Automatic
"STRAIGHT-LINE" TEMPERATURE CONTROL with XACTLINE

ELIMINATE
Overshooting
Undershooting

Are you going to continue to put up with that troublesome overshooting and undershooting inherent in your conventional pyrometer control—especially when it is so easy to eliminate that saw-tooth effect?

Put XACTLINE in the control circuit. XACTLINE anticipates the temperature changes—before they occur. And too, it nullifies the varying amounts of thermal lag, residual heat, and mechanical lag—producing a short on-off cycle resulting in "Straight-Line" temperature control. This performance is possible because there is no dependence upon mechanical parts—XACTLINE operates electrically.



Exact reproduction of temperature chart for a heating process showing the comparison of the "Straight-Line" temperature control produced by XACTLINE and the saw-tooth curve obtained with only conventional control.

XACTLINE is applicable to any indicating or recording pyrometer control of the millivoltmeter or potentiometer type. It should be used wherever close temperature control is required—any type of electrically heated oven, furnace, kiln, injection molding machine, and fuel-fired furnaces equipped with motor-operated or solenoid valves.

XACTLINE is a complete unit. No adjustment or coordination with the control instrument is required regardless of the size of the furnace, length of the heating cycle, or size of the load. Installation is very simple—can be either flush or surface mounted.

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 731.

S-387 AIR CONTROL VALVES. 8-page Bulletin 101 illustrates and describes maker's valves for controlling single- and double-action air cylinders on chucks, vises, lathes, screw machines, special machine tools, etc.; covers applications, sizes on all types.—Ross Operating Valve Co., Detroit 3, Mich.

S-388 NEGATIVE-GRADIENT ELASTIC MEMBER. 4-page Bulletin 310A describes and illustrates four major forms (extension spring, type A motor, type B motor, clamps) of the "Neg'ator" (see New Instrument item 803, page 700, Instruments, August 1949).—Hunter Spring Co., Lansdale, Pa.

S-389 "FUNCTIONAL PHOTOGRAPHY IN BUSINESS AND INDUSTRY." 16-page booklet describes and illustrates applications and techniques of photography in business and industry.—Industrial Photographic Div., Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

S-390 OPTICAL INSTRUMENTS. Portfolio of 16 data sheets illustrates and describes (foreign-made) optical instruments to test alignment, angles, and inclinations (auto-collimator, surface alignment telescope & target, levels, angle gages, etc.), instruments and tools for circular spacing (circular division tester, circular table, circular and linear dividing machines), shop microscopes.—Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.

S-391 AUTOMATIC MOISTURE ELIMINATOR. 4-page brochure illustrates and describes maker's "Drain Master" pet cock for automatically eliminating moisture from compressor tanks, air lines and air brake systems; lists advantages, price.—Master Equipment Sales, P. O. Box 55, Dayton 1, Ohio.

S-392 CHLORINE WATER TREATMENT. 4-page Bulletin A-1A-4 titled "Chlorine Treatment of Municipal Water" summarizes present day processes and equipment; contains flow diagrams and illustrations.—Fischer & Porter Co., 1000 County Line Rd., Hatboro, Penna.

S-393 HIGH-FIDELITY REPRODUCER EQUIPMENT. 6-page Bulletin 44N26 illustrates and describes maker's line of high-fidelity equipment; covers cone speakers, tweeters, tweeter adapters, crossover networks and coaxial speaker systems; gives complete installation instructions for each model.—University Loudspeakers, Inc., 80 S. Kensico Ave., White Plains, N. Y.

S-394 CONTROLLED VOLUME PUMPING. 16-page Bulletin 450 describes and illustrates maker's air-cylinder powered chemical pumps, automatic chemical feed systems and automatic hydrostatic test pressure systems for controlled volume pumping; covers applications, design details and advantages.—Milton Roy Co., 1300 E. Mermaid Lane, Chestnut Hill, Philadelphia 18, Penna.

S-395—SYNCHRO UNITS. 12-page bulletin illustrates and describes maker's synchro units for transmitting, by single-phase a.c., a continuous accurate indication of angular position; covers features; contains outline drawings.—Arma Corp., 254 36th St., Brooklyn 32, N. Y.

S-396 UNIVERSAL TESTING MACHINE. 4-Page Bulletin 310 describes and illustrates maker's "Model 60-H" 60,000-lb. universal testing machine; covers features, specifications.—Testing Equipment Dep't, The Baldwin Locomotive Works, Philadelphia 42, Penn.

S-397 "EBERBACH ANNOUNCER." 16-page No. 50-3-38 issue of this house organ features articles on nephelometry, on maker's "Dyna-Cath" magnetic mercury cathode, and other of maker's laboratory equipment.—Eberbach & Son Co., 200 E. Liberty St., Ann Arbor, Mich.

S-398 FLOW MEASUREMENT. 32-page Data Book No. 702 illustrates and describes maker's flow meters. Five sections cover theory of operation, meter bodies, differential devices, reading instruments, special applications for measurement of reverse or extremely wide range flows.—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

S-399 WATTHOUR METER BOOKLET. 28-page booklet titled "What It Takes for Long-time, Low-cost "Metering" discusses assembly, accuracy, maintenance, calibration, corrosion resistance of watthour meters; illustrates and describes types of maker's meters and applications.—Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Penna.

S-400 MERCURY MANOMETER FLOWMETERS. 12-page Catalog 37 illustrates and describes maker's mercury manometer flowmeters; covers features, engineering and specification data; discusses use in automatic ratio control.—Fischer & Porter Co., Hatboro, Penna.

S-401 AREA TYPE FLOWMETER. 12-page Catalog 83 describes and illustrates maker's "Ratosleeve" variable-area type flow-rate instrument; covers advantages, sizes and models, installation, dimensions.—Fischer & Porter Co., Hatboro, Penna.

S-402 PRODUCTIVITY SLIDE-RULE. 4-page bulletin illustrates and describes maker's "Productivity-Scope" slide-rule for measuring and indicating performance while a job is running.—R. G. Bock Engineers, Lincoln Nat'l. Bank Bldg., 1951 Irving Park Rd., Chicago 13, Ill.

S-403 INTERCHEMICAL DRY THICKNESS GAGE. 4-page bulletin describes and illustrates maker's Interchemical direct-reading thickness gage for measuring foils or unattached sheet materials, also to determine thickness of attached coatings.—Henry A. Gardner Lab., Inc., 4723 Elm St., Bethesda, Md.

S-404 FEEDER VOLTAGE REGULATORS. 16-page bulletin illustrates and describes maker's transformer-type "AFR" feeder voltage regulators; covers construction, maintenance, automatic control, theory of operation, standard ratings.—Allis-Chalmers, Milwaukee 1, Wis.

S-405 TIN CONTENT INDICATOR. 2-page Bulletin TI-1 describes and illustrates maker's portable tin content indicator for solder; covers features, principle of operation, specifications.—Wheelco Instruments Co., Chicago 7, Ill.

S-406 RESISTORS. 6-page Resistor Bulletin 350 describes maker's standard, non-standard, adjustable, ferrule terminal and "Blue Ribbon" (mounted with aluminum through-bar) resistors; covers features, specifications, mounting brackets and accessories.—Hardwick-Hindle, Inc., Newark 5, N. J.

S-407 A-C. MAGNETIC STARTERS. 4-page Bulletin 4120 illustrates and describes maker's combination across-the-line type a-c. magnetic starters; covers features, application, construction, ordering information.—Ward Leonard Electric Co., Mount Vernon, N. Y.

S-408 TEMPERATURE AND PRESSURE INSTRUMENTS. 12-page Preliminary Issue Catalog 86 describes and illustrates maker's "Ratotherm" and "Ratogage" temperature and pressure instruments; covers construction; characteristics.—Fischer & Porter Co., Hatboro, Penna.

S-409 FUEL INJECTION TEST EQUIPMENT. 8-page bulletin illustrates and describes maker's standardized fuel injection test equipment (max. pressure indicators, pump and governor test bench, dynamic pressure gage, etc.);

covers features, specifications.—Ferrier Engineering 185 Breckwood Blvd., Springfield, Mass.

S-410 RECORDING COUNTERS. 4-page bulletin describes and illustrates maker's recording mechanical counters; covers features, advantages, applications, specifications.—Streeter-Amet Co., 4101 Ravenswood Ave., Chicago 13, Ill.

S-411 DIFFUSION PUMP. 6-page bulletin describes and illustrates maker's "HV-1" vacuum oil-diffusion pump; covers operational and mechanical data, application.—Eitel-McCullough, Inc., San Bruno, Calif.

S-412 PRESSURE TEST UNIT. 8-page bulletin illustrates and describes maker's "Twin-Seal" pressure test unit for general purpose instrument testing and maintenance; covers features; lists price schedule for unit and accessories.—Mansfield & Green, 1051 Power Ave., Cleveland 14, Ohio.

S-413 "BIDDLE INSTRUMENT NEWS." 4-page Vol. 6, No. 2 issue of this house organ features articles on new series of "Megger" megohmmeter, on origin of "Megger" insulation testers.—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pena.

S-414 ELECTRONIC PHASE ADAPTER. 6-page bulletin describes maker's "Model 160" electronic phase adapter; covers features, specifications.—Varo Mfg. Co., Box 638, Garland, Texas.

S-415 "PRECISIONOMICS." 4-page Vol. 2, No. 2 issue of this house organ features articles on maker's Latex stability tester, Reid vapor pressure bombs and other laboratory equipment.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

S-416 LABORATORY APPARATUS CATALOG. 24-page catalog (Number 10) entitled "What's New for the Laboratory?" illustrates and describes maker's apparatus, instruments, chemicals, glassware (automatic titrator, balances, vacuum pumps, polarimeter, etc.); covers features, characteristics of each item.—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

S-417 "hp JOURNAL." 4-page Vol. 1, No. 9 issue of this house organ features article titled "Direct Reading UHF Power Measurements."—Hewlitt-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.

S-418 SOLENOID VALVES. 2 bulletins, No. 505 and No. 501, illustrate and describe maker's solenoid valves. No. 505 covers complete details on "V-5, M-2 and M-3" series; No. 501 gives complete data and specifications on "V-5" series.—Skinner Electric Valve Div., The Skinner Chuck Co., Norwalk, Conn.

S-419 "SPECTROGRAPHER'S NEWSLETTER." 4-page Vol. 3, No. 5 issue of this house organ features article titled "Quantometer Analysis of Phosphorus in Steels," also features description of new book, "Spectrochemical Procedures," on emission spectrum analysis.—Applied Research Laboratories, 4336 San Fernando Rd., Glendale 4, Calif.

S-420 STEAM HOOK-UPS. 64-page sixth enlarged edition covers maker's steam hook-ups for steam traps, air vents and industrial temperature controllers; contains additional technical information.—Sarco Co., Inc., Empire State Bldg., New York 1, N. Y.

S-421 CUSTOM-BUILT ELECTRICAL ENCLOSURES. 16-page Bulletin EE illustrates and describes maker's fabricated control desks, cubicles, electrical cabinets and enclosures, test stands, instrument panels, etc.—The Kirk & Blum Mfg. Co., 2854 Spring Grove Ave., Cincinnati, Ohio.

S-422 LABORATORY APPARATUS. 44-page catalog illustrates and describes scientific laboratory apparatus (centrifuges, convection ovens, photoelectric and electronic measuring instruments, furnaces, high-frequency combustion units, etc.); covers features, advantages, specifications of each model.—Boder Scientific Co., 719-721 Liberty Ave., Pittsburgh 22, Penna.

S-423 SMOKE AND COMBUSTION INSTRUMENTS. 8-page Bulletin 501 describes and illustrates maker's "Electric Eye" smoke and combustion instruments; covers features, advantages, applications, performance data.—Ess Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.

S-424 AIR FLOW MEASUREMENT. 4-page Bulletin A-7 illustrates and describes maker's "Tool-om-eter and Drill-om-eter" devices for measuring air consumption of pneumatic tools, drills, etc.; covers dimensions, principle, operation, and applications.—New Jersey Meter Co., Plainfield, N. J.

S-425 AUTOMATIC COMPRESSED AIR SEPARATOR. 4-page Bulletin DA illustrates and describes maker's "DriAir" automatic compressed air separator; covers features, operation, capacities.—New Jersey Meter Co., Plainfield, N. J.

S-426 SERVO TORQUE UNIT. 4-page Engineering Data Sheet describes and illustrates maker's "Model ST-411" servo torque unit; covers features, construction, operation, application.—Servo-Tek Products Co., Inc., 4 Godwin Ave., Paterson 1, N. J.

S-427 ULTRASENSITIVE RELAY. 4-page Bulletin No. 59 illustrates and describes maker's ultrasensitive electronic relay; covers features, specifications; contains installation diagram.—Servo-Tek Products Co., Inc., 4 Godwin Ave., Paterson 1, N. J.

S-428 ROUGHNESS MEASUREMENT. 4-page bulletin illustrates and describes maker's "Profilometer" tracers for roughness measurement; covers range of work, piloting methods.—Physicists Research Co., 321 S. Main St., Ann Arbor, Mich.

S-429 "THE GENERAL RADIO EXPERIMENTER." 12-page Vol. 24, No. 12 issue of this house organ features articles on maker's "Type 1602-A" direct-reading impedance-measuring instrument for the UHF range, and other equipments.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

S-430 "THE C-D CAPACITOR." 16-page Vol. 15, No. 5 issue of this house organ features article titled "The Magnetic Amplifier," also regular feature "The Radio Trading Post—A Free Market-place for Buyers, Sellers, and Swappers."—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

S-431 MECHANICAL RECORDERS. 4-page bulletin describes and illustrates maker's mechanical recorders for science and industry; covers features, applications, specifications.—Streeter-Amet Co., 4101 N. Ravenswood Ave., Chicago 13, Ill.

S-432 ELECTRIC TIMING DEVICES. 8-page Catalog 323 illustrates and describes maker's reset timers, interval timers, elapsed time indicators, fixed interval repeat cycle timers, etc.; covers features, specifications.—Haydon Mfg. Co., Inc., Torrington, Conn.

S-433 "S-L INSTRUMENT NOTES." 4-page No. 14, March-April 1950 issue of this house organ features article titled "Calibration of Resistance Bridge Transducer Circuits under Temperature Extremes," also describes maker's "Model P11" pressure transducer.—Statham Laboratories, Inc., 9328 Santa Monica Blvd., Beverly Hills, Calif.

S-434 LABORATORY OVENS. 8-page Bulletin 376 illustrates and describes maker's "Thelco" laboratory ovens and incubators; covers features, specifications, data for ordering.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

S-435 VACUUM PUMP. 2-page sheet contains price list for maker's vacuum pumps and pump parts.—Eitel-McCullough, Inc., San Bruno, Calif.

S-436 AUTOMATIC BAGGING SCALE. 2-page Bulletin 4916 illustrates and describes maker's "Model E-50" heavy-duty dust-proof portable automatic bagging scale; covers specifications and features.—Richardson Scale Co., Clifton, N. J.

S-437 DENSITOMETER. 16-page bulletin illustrates and describes maker's "Densichron" densitometer for science, industry, and the graphic arts; covers maker's system of "magnetic modulation," also covers amplification, sensitivity, specifications, applications.—W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago 10, Ill.

S-438 PYROMETER CONTROLLER. 4-page Bulletin J-1 describes and illustrates maker's "Gardsman" indicating pyrometric controller; covers operation, features, wiring, specifications, standard scale ratings.—Taco West Corp., 525 N. Noble St., Chicago 22, Ill.

S-439 RADIO AND TELEVISION EQUIPMENT CATALOG. 48-page catalog, Special Supplement No. 123, illustrates, describes and lists prices on maker's radio and television equipment

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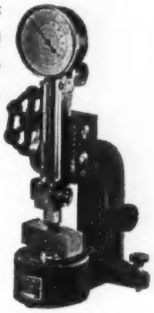

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S-440 "SCIENTIFIC APPARATUS AND METHODS." 36-page, Vol. 3, Spring 1950 issue of this house organ features in section one, articles titled "The Polarography of Vitamins" and a picture story "New Facilities Climax a Century of Progress." Section two covers maker's new, reinstated and discontinued items, and changes in specifications.—E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Ill.

S-441 RADIO TUBE CHARACTERISTICS. 28-page bulletin contains maker's radio tube characteristics chart, also covers tube type base arrangements, panel lamp characteristics, germanium diodes, and crystal diode polarity.—Sylvania Electric Products, Inc., Emporium, Penna.

S-442 TRANSMITTING TUBES. 12-page bulletin contains maker's transmitting tube characteristics chart.—Sylvania Electric Products, Inc., Emporium, Penna.

S-443 "ELECTRON TUBES APPLICATION NOTE." Two of maker's publications, titled "Electron Tubes Application Note"—An-143 features article "Use of Sharp-cutoff Miniature Pentode 6CB6 in Television Receivers"; and AN-142 features article "High-efficiency Deflection and High-voltage Circuits for Short Metal Kinescope 16GP4."—Tube Dep't, Radio Corp. of America, Harrison, N. J.

S-444 "LANCO APPARATUS NEWS." 4-page Vol. 2, No. 2 issue of this house organ features articles on laboratory shakers, precision-bore burettes, beakers, etc; includes features, sizes.—Arthur S. LaPine & Co., 121 W. Hubbard, Chicago 10, Ill.

S-445 A-C. VOLTAGE SUPPLY. 2-page Bulletin CVL-140 illustrates and describes maker's "Type CVL" a-c. voltage supply; covers features, dimensions, specifications.—Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.

S-446 MATCHED TV TESTERS. 4-page bulletin illustrates and describes maker's oscilloscopes, sweep and marker generators, tube testers, audio oscillators, etc.; covers features, ranges, prices.—Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 2, Ohio.

S-447 MULTIPLE-PURPOSE ELECTRICAL TESTER. 2-page bulletin illustrates and describes maker's "Model 632" multiple-purpose electrical tester, also "Model 665" composite video generator; covers features of both, ranges on former.—Supreme, Inc., Greenwood, Miss.

S-448 WIDE-RANGE OSCILLOSCOPE. 2-page bulletin illustrates and describes maker's "Model 660" wide range 5-in. oscilloscope, and "Models 655 and 650" oscilloscopes; covers features and specifications.—Supreme, Inc., Greenwood, Miss.

S-449 D.C. to A.C. CONVERTERS. 16-page Catalog 349 illustrates and describes maker's d.c. to a.c. converters; covers features, specifications, characteristics, and dimensions for various models.—Carter Motor Co., 2644 N. Maplewood Ave., Chicago 47, Ill.

S-450 MICROWAVE TEST SET. 4-page bulletin describes and illustrates maker's "Type H-10" microwave test set; covers features, specifications.—Aircraft Radio Corp., Boonton, N. J.

S-451 INDUCTOR ALTERNATORS. 2-page Bulletin 350 illustrates and describes maker's inductor alternator high frequency rotary power supply; covers features, ratings, specifications.—Carter Motor Co., 2644 Maplewood Ave., Chicago 47, Ill.

S-452 UHF SIGNAL GENERATOR. 4-page bulletin describes and illustrates maker's "Type H-12" UHF signal generator; covers features, specifications.—Aircraft Radio Corp., Boonton, N. J.

S-453 DYNAMOTOR POWER SUPPLY. 2-page Bulletin No. 450 illustrates and describes maker's "Multi-magmotor" dynamotor power supply; covers features, specifications, weights, dimensions.—Carter Motor Co., 2644 Maplewood Ave., Chicago 47, Ill.

S-454 MINIATURE INSPECTION LAMPS. Two bulletins, one on battery-operated lamps, the other (Bulletin 101) on a-c. operated lamps, describe and illustrate maker's miniature inspection lamps for hard-to-get-at places; cover features, specifications, prices.—Eder Instrument Co., 1849 N. Halsted St., Chicago 14, Ill.

S-455 DYNAMOMETER POWER SUPPLIES. 24-page Catalog 649 describes and illustrates various models of maker's dynamometer power supplies; covers features, specifications, advantages; also contains performance charts, engineering notes and general information.—Carter Motor Co., 2644 N. Maplewood Ave., Chicago 47, Ill.

S-456 SATURATION RECORDER-CONTROLLER. 12-page Catalog 1287 illustrates and describes maker's "Model 8178" TAG saturation recorder-controller for control of moisture and oil saturation of natural gas in gas mains; covers features, operation, installation, specifications; also contains parts and price lists.—Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

S-457 PRINTING COUNTERS. 2-page brochure illustrates and describes maker's stroke, rotary, and electrical "Productimeter" printing counters; covers features, advantages.—Durant Mfg. Co., 1990 N. Buffum St., Milwaukee 1, Wis.

S-458 "COOK DIAPHLEX NEWSLETTER." 4-page Vol. 1, No. 13 issue of this house organ features article on maker's "Diaphlex" miniature components (d-c. contactor relay, miniature multi-contact relay, 2-stage 100,000 gain amplifier, rectifier cells, etc.); covers features, performance, dimensions.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

S-459 EXHIBITING AND CONTROLLING INSTRUMENTS. 28-page Catalog 50 describes and illustrates maker's exhibiting and controlling flow instruments for industry; covers flow indicators, recorders, integrators, new pneumatic controller unit; also describes maker's "Magnabond" close-couple transmission, and electric impedance bridge transmitting systems.—Fischer & Porter Co., 50 County Line Road, Hatboro, Penna.

S-460 INDUCTION MOTORS AND GENERATORS. 16-page bulletin illustrates and describes maker's induction motors and generators for instrumentation and control work; covers features, specifications, performance curves, outline drawings.—Arma Corp., 254 36th St., Brooklyn 32, N. Y.

S-461 "CEC RECORDINGS." 12-page Vol. 4, No. 2 issue of this house organ features articles titled "Recording Galvanometers and How to Use them," "Biological Nitrogen Fixation at University of Wisconsin," also articles on maker's vibration meters and other devices.—Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif.

S-462 SOIL TESTERS. 16-page Booklet 695 describes and illustrates maker's soil reaction, and combination soil testers; covers features, advantages, replacements, and prices.—Hellige, Inc., 3718 Northern Blvd., Lond Island City 1, N. Y.

S-463 OIL COMPARATOR AND COLORIMETER. 4-page Catalog 605-50 illustrates and describes maker's oil comparator and oil colorimeter for color determinations of lubricating oil and petrolatum; covers features, applications, specifications, prices.—Hellige, Inc., 3718 Northern Blvd., Long Island City 1, N. Y.

S-464 LABORATORY WORK CABINET. 6-page folder describes and illustrates maker's (The Baker Co.) "Sterilshield" cabinet, an enclosed laboratory workbench; covers features, construction, specifications.—The McDonald Co., 43 Lansdowne St., Boston 15, Mass.

S-465 GAS DETECTOR AND CONTROL SYSTEM. 8-page bulletin describes and illustrates maker's combustible gas detector and automatic control system for safe handling of explosive gases; covers features, construction, performance data, applications.—The Lor-Ann Instrument Co., 58 Montgomery St., Jersey City 2, N. J.

S-466 "THE PERKIN-ELMER INSTRUMENT NEWS." Vol. 1, No. 3 issue of this house organ features articles titled "Flame Temperature Measured by Infrared Techniques," "European Applications of Electrophoresis," "Instrumentation in the Hospital Clinical Laboratory"; also contains articles on maker's infrared spectrometers and other equipment.—The Perkin-Elmer Corp., Glenbrook, Conn.

S-467 "ELECTRICAL MEASUREMENTS." 4-page issue of this house organ features articles on maker's volt-amp-wattmeter; covers features, advantages, specifications.—Sensitive Research